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# Soil Survey

# The Lower Yellowstone Valley Area Montana

By

WILLIAM DeYOUNG, in Charge, and F. K. NUNNS

Montana Agricultural Experiment Station

and

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United States Department of Agriculture

UNITED STATES DEPARTMENT OF AGRICULTURE

In cooperation with the

Montana Agricultural Experiment Station

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CONTENTS

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# SOIL SURVEY OF THE LOWER YELLOWSTONE VALLEY AREA, MONTANA

By WILLIAM DeYOUNG, in Charge, and F. K. NUNNS, Montana Agricultural Experiment Station, and L. H. SMITH, Bureau of Chemistry and Soils, United States Department of Agriculture

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## AREA SURVEYED

The lower Yellowstone Valley area follows the lower valley of Yellowstone River through Prairie, Dawson, and Richland Counties in eastern Montana to the junction of that river with the Missouri (fig. 1). A few islands, which are a part of Wibaux County, are in the channel of the river. The area is long and narrow. Its width ranges from about 2 to 8 miles, and its length is about 130 miles. The boundaries are irregular, but they more or less parallel Yellowstone River. The lower ends of the small tributary valleys, as well as bordering areas of uplands and slopes on each side of the main valley, are included.

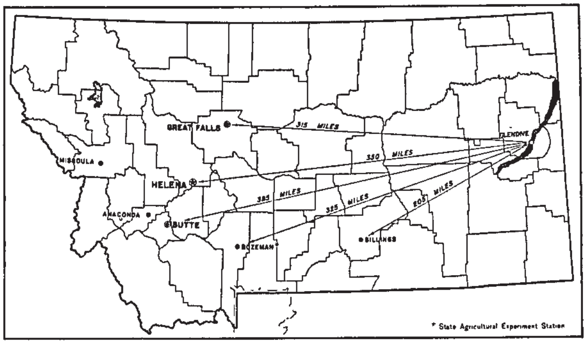


FIGURE 1.—Sketch map showing location of the lower Yellowstone Valley area, Montana.

A part of McKenzie County, N. Dak., lies on the western side of the Yellowstone, and agriculturally and economically is closely related to the lower Yellowstone Valley area, Montana. A soil map of this North Dakota area has, therefore, been indicated (without color) adjoining the lower Yellowstone Valley area, Montana. As the latter area is less detailed than surveys ordinarily published now as detailed surveys, the small section that lies in North Dakota has been compiled by generalization of the very detailed map of McKenzie County (*2*)[1] and does not include all the soil types and phases shown on that map.

The lower Yellowstone Valley area, Montana, embraces 412 square miles, or 263,680 acres.

The purpose of this survey is to provide basic information regarding the soils of the area that now are under irrigation and those that may be irrigated in the future.

[1] Italic numbers in parentheses refer to Literature Cited, p. 35.

128330—39——1

In general, the area dissected by the valley of the Yellowstone River may be characterized as a plain which slopes toward the north and east. This valley is old and has not been changed by glaciation as has the valley of Missouri River. Slight influence of glaciation is evident, however, in the lower or northern part (roughly between Intake and Missouri River), where the bordering uplands on the northern and western sides of the valley are, in general, well rounded and gently sloping.

The geologic materials underlying this area consist of alternating beds of sandstones and shales of different formations. On the basis of degree of dissection, which depends on the hardness and resistance of these materials, three types of topography are developed: (1) Badlands where deep gullies and prominent cliffs predominate, (2) gently rolling uplands removed from stream courses, and (3) hilly broken uplands where hard sandstones and scoria beds resist erosion.

An outstanding characteristic of the Yellowstone Valley is the presence of benches or terraces which border the recent alluvial bottoms on each side of the river. In places, a series of two or three terraces are evident. The higher terraces generally are the largest and best developed. The most prominent high terraces bordering the lower Yellowstone Valley area are the three flats located on the southern side of the valley from Marsh to Terry. These terraces are the result of successive cutting of the river in a past geologic age. The high terraces invariably face the present river valley with steep fronts. Springs are numerous along the fronts of some of these terraces, especially south of Terry.

The lower or more recent alluvial bottoms of the main valley are in general fairly flat, but actually many miniature terraces and low swales indicate former overflow channels of the river. Leveling is necessary in many places before the land can be properly irrigated. Series of shallow sloughs separated by sand bars border the present stream channel in places.

The elevation of the valley and the fall of Yellowstone River are shown by the elevations of the Northern Pacific and the Great Northern Railway stations along their routes. At Benz, near the western edge of the area, the elevation is 2,289 feet above sea level. Northeastward from Benz, the elevations are: Terry 2,264 feet, Glendive 2,091 feet, Sidney 1,948 feet, and Fairview 1,902 feet. The distance by rail from Benz to Fairview is 119 miles. The elevation at the confluence of the Yellowstone and Missouri Rivers is somewhat less than 1,900 feet. The valley benches rise from 10 to 350 feet above the valley floor; the more prominent buttes and cliffs, such as Eagle Butte south of Glendive, rise from 200 to 375 feet above the valley.

Natural drainage ranges from good to excessive throughout the Yellowstone Valley, except in certain depressions in which the soil is heavy and in places where seepage from the bordering uplands takes place. Under irrigation, however, natural moisture conditions are materially changed, especially where seepage losses from the main canal are heavy or where the excessive use of water produces a high water table.

Although an excellent drainage system has been provided in the lower Yellowstone project, considerable damage from seepage

and alkali occurred before drainage was provided. In the heavy and low-lying soil areas, drainage is slow and reclamation is difficult. The areas most seriously affected by seepage and alkali are those east of Ridgelawn, on the bottoms of Fox Creek west and south of Newton, south of Hoffmanville, and north of Savage. All these areas are under the main canal of the lower Yellowstone project. Areas at the mouth of Bad Route Creek and in the vicinity of Terry also are affected by seepage from the bordering uplands.

The native vegetation of eastern Montana is a short-grass association. The dominant grasses are blue grama (*Bouteloua gracilis*), bluestem, or western wheatgrass (*Agropyron smithii*), needle-and-thread (*Stipa comata*), threadleaf sedge, or niggerwool (*Carex filifolia*), and junegrass (*Koeleria cristata*).

Previous to 1877 all the plains area was included in Dawson County. Custer County was later created on the west. Richland and Prairie Counties were established in 1914 and 1915, respectively.

Many of the present settlers on the irrigated lands are of foreign birth, largely Norwegians, Germans, and Russians. The development of the irrigated lands has not been as rapid as was at first expected because of a number of difficulties, largely financial.

According to the annual census taken by the Bureau of Reclamation in 1937, the population on farms in the lower Yellowstone project, which extends from Intake to the Missouri River, is 2,760. About 4,000 people obtain their livelihood, either directly or indirectly, from the farming of irrigated lands. These people live mostly in Richland County and in McKenzie County, N. Dak. At the time of this survey only 65 farms in Dawson County and 22 farms in Prairie County were situated in the Yellowstone Valley.

The most important towns in the valley are Fairview, Sidney, Glendive, Fallon, and Terry. According to the 1930 census, Sidney, the county seat of Richland County, has a population of 2,010. It has a beet-sugar factory, a flour mill, and a seed house. It is connected with branch lines of both the Great Northern and the Northern Pacific Railways. Fairview, an important trading center in the northern part of the area, is situated on the Montana-North Dakota State line and includes 576 inhabitants. Glendive, with a population of 4,629, is the county seat of Dawson County. With its repair shop and yard facilities, it is an important division point on the Northern Pacific Railway. It has direct railroad service to Pacific coast points and Minneapolis, St. Paul, and Chicago. Terry, with a population of 779, is the county seat of Prairie County. It is served by the main lines of both the Northern Pacific Railway and the Chicago, Milwaukee, St. Paul, & Pacific Railroad. Fallon is an important trading center for the eastern part of Prairie County.

Most of the towns in the lower Yellowstone Valley area have excellent schools and modern municipal improvements. Many religious denominations are represented with church organizations and places of worship.

Two transcontinental railroads, namely, the Northern Pacific Railway and the Chicago, Milwaukee, St. Paul & Pacific Railroad, serve parts of the area, and branch lines of the Northern Pacific and the Great Northern Railways serve the lower Yellowstone (irrigation)

project. United States Highway No. 10 enters the valley at Glendive and traverses the valley westward. A State highway traverses the lower valley and connects with North Dakota highways to Williston.

## CLIMATE

The climate of the lower Yellowstone Valley area is characterized by moderately low annual precipitation, a dry atmosphere, hot summers, cold winters, and a large proportion of sunny days. During summer there are from 14 to 16 hours of daylight. The valley, particularly during the winter, is subject to the frequent sudden changes characteristic of the northern Great Plains.

Climatic data, compiled from records of the United States Weather Bureau stations at Savage, Glendive, and Miles City, which are representative of the Yellowstone Valley, are summarized in tables 1, 2, and 3. The records of the Miles City station are the longest in this part of the State. This station is situated about 40 miles west of Terry.

TABLE 1.—*Normal monthly, seasonal, and annual temperatures at Savage, Richland County; Glendive, Dawson County; and Miles City, Custer County, Mont.*

| Month | Savage (elevation, 1,985 feet) | | | Glendive (elevation, 2,090 feet) | | | Miles City (elevation, 2,351 feet) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Maximum | Minimum | Mean | Maximum | Minimum | Mean | Maximum | Minimum |
| | °F. | °F. | °F. | °F. | °F. | °F. | °F. | °F. | °F. |
| December | 17.5 | 58 | −41 | 18.4 | 63 | −40 | 21.0 | 64 | −52 |
| January | 12.8 | 60 | −46 | 14.1 | 63 | −48 | 14.5 | 57 | −65 |
| February | 17.6 | 70 | −53 | 16.5 | 73 | −50 | 16.9 | 68 | −49 |
| Winter | 16.0 | 70 | −53 | 16.3 | 73 | −50 | 17.5 | 68 | −65 |
| March | 29.1 | 78 | −28 | 28.8 | 85 | −30 | 28.6 | 88 | −38 |
| April | 45.0 | 95 | −4 | 46.2 | 93 | −6 | 44.7 | 90 | −7 |
| May | 55.5 | 104 | 18 | 56.6 | 104 | 16 | 56.7 | 101 | 17 |
| Spring | 43.2 | 104 | −28 | 43.9 | 104 | −30 | 43.3 | 101 | −38 |
| June | 65.5 | 109 | 29 | 66.2 | 109 | 29 | 66.0 | 108 | 33 |
| July | 71.9 | 111 | 37 | 73.2 | 113 | 37 | 72.9 | 112 | 31 |
| August | 69.0 | 107 | 28 | 70.7 | 111 | 32 | 71.5 | 112 | 32 |
| Summer | 68.8 | 111 | 28 | 70.0 | 113 | 29 | 70.1 | 112 | 31 |
| September | 58.5 | 101 | 16 | 58.6 | 103 | 16 | 61.2 | 102 | 16 |
| October | 45.6 | 92 | −14 | 46.6 | 92 | −13 | 46.5 | 94 | −5 |
| November | 31.4 | 74 | −20 | 32.5 | 76 | −20 | 30.9 | 76 | −26 |
| Fall | 45.2 | 101 | −20 | 45.9 | 103 | −20 | 46.2 | 102 | −26 |
| Year | 43.3 | 111 | −53 | 44.0 | 113 | −50 | 44.3 | 112 | −65 |

The winter and summer extremes of temperature in the lower Yellowstone Valley differ greatly; the highest temperature of 113° F. was recorded at Glendive and the lowest temperature −65°, at Miles City. These extreme temperatures are seldom reached and are of short duration. The mean annual temperature ranges from 43.3° at Savage to 44.3° at Miles City. The average frost-free period ranges from 129 days at Savage to 154 days at Miles City, and in normal seasons killing frosts seldom occur after May 20 or earlier than September 20. Late spring frosts rarely damage small grains or sugar beets, but early fall frosts may do considerable damage.

TABLE 2.—*Normal monthly, seasonal, and annual precipitation at Savage, Richland County; Glendive, Dawson County; and Miles City, Custer County, Mont.*

| Month | Savage | | | Glendive | | | Miles City | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Total amount for driest year (1934) | Total amount for wettest year (1916) | Mean | Total amount for driest year (1934) | Total amount for wettest year (1916) | Mean | Total amount for driest year (1934) | Total amount for wettest year (1879) |
| | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* |
| December | 0.51 | 0.25 | 1.10 | 0.56 | 0.22 | 1.25 | 0.63 | 0.35 | 0.58 |
| January | .41 | .11 | .99 | .44 | .13 | .91 | .66 | .12 | .26 |
| February | .43 | (1) | .23 | .44 | .05 | .04 | .51 | .05 | .69 |
| Winter | 1.35 | .36 | 2.32 | 1.44 | .40 | 2.20 | 1.80 | .52 | 1.53 |
| March | .65 | .61 | .73 | .80 | 1.04 | .35 | .86 | 1.05 | .28 |
| April | .85 | .46 | .45 | 1.06 | .09 | .25 | 1.12 | .40 | 2.20 |
| May | 2.00 | .15 | 1.27 | 2.11 | .15 | 1.21 | 2.24 | .34 | 2.75 |
| Spring | 3.50 | 1.22 | 2.45 | 3.97 | 1.28 | 1.81 | 4.22 | 1.79 | 5.23 |
| June | 3.08 | 1.90 | 4.35 | 3.32 | 1.98 | 5.22 | 2.66 | .66 | 5.23 |
| July | 1.79 | 1.61 | 4.16 | 1.84 | .59 | 4.96 | 1.54 | .67 | 5.90 |
| August | 1.52 | .32 | 3.13 | 1.50 | .11 | 6.29 | 1.08 | .42 | 1.84 |
| Summer | 6.39 | 3.83 | 11.64 | 6.66 | 2.68 | 16.47 | 5.28 | 1.75 | 12.97 |
| September | 1.25 | .37 | 1.77 | 1.37 | .32 | 4.37 | 1.04 | 1.04 | .44 |
| October | .74 | .12 | .71 | .85 | .08 | .67 | .90 | .03 | 2.47 |
| November | .40 | .03 | .29 | .42 | .07 | .50 | .57 | .38 | .11 |
| Fall | 2.39 | .52 | 2.77 | 2.64 | .47 | 5.54 | 2.51 | 1.45 | 3.02 |
| Year | 13.63 | 5.93 | 19.18 | 14.71 | 4.83 | 26.02 | 13.81 | 5.51 | 22.75 |

[1] Trace.

TABLE 3.—*Frost data recorded at Savage, Richland County; Glendive, Dawson County; and Miles City, Custer County, Mont.*

| Station | Average date of last killing frost | Average date of first killing frost | Average frost-free period | Latest recorded date of killing frost | Earliest recorded date of killing frost |
|---|---|---|---|---|---|
| | | | *Days* | | |
| Savage | May 19 | Sept. 25 | 129 | June 16 | Sept. 7 |
| Glendive | May 14 | Sept. 23 | 132 | June 9 | Aug. 25 |
| Miles City | May 1 | Oct. 2 | 154 | May 31 | Sept. 6 |

The annual precipitation in the lower Yellowstone Valley area differs considerably from year to year, as does also its distribution throughout the growing season. During wet years, such as 1906, 1915, 1916, and 1927, little irrigation was necessary, and then only for such crops as sugar beets and alfalfa, but during the dry years of 1930 and 1931 all nonirrigated crops were practically a failure. The average annual rainfall recorded for the different Weather Bureau stations ranges from 13.63 to 14.71 inches, and usually about 60 percent of the total is received between April 1 and September 1, when it is most needed by the growing crops. The heaviest rainfall generally occurs during May and June. July and August are the months when water for irrigation is most needed, particularly for alfalfa, sugar beets, and pastures. An average of 25.2 inches of snow

falls at Savage, 32.6 inches at Glendive, and 31.8 inches at Miles City.

Although strong winds are not so frequent or so severe as in the northwestern part of the Plains area, it seems that in southeastern Montana they have caused considerable soil drifting in the drier years, particularly in areas where the roots and other fibrous organic matter in the soil have been destroyed through cultivation. Hot winds from the south and southeast have caused serious losses to nonirrigated crops in the dry years. Local hailstorms of more or less severity occur during the summer but are no more frequent than in other parts of the Great Plains.

The prevailing winds at Savage are from the west; at Glendive, from the southwest; and at Miles City, from the south.

## AGRICULTURAL HISTORY AND STATISTICS

Probably one of the first white men to see eastern Montana was Captain Clark of the Lewis and Clark Expedition, who came down the Yellowstone Valley in 1806. Fur traders and roaming stockmen were the first to explore and determine the resources of the country. Not until 1877, when a number of temporary military posts were established along Yellowstone River and afforded protection, were the first few settlements started. Fort Keogh was established at this time near the present site of Miles City.

Settlers began to rush in just before the construction of the Northern Pacific Railway, which reached this territory in 1881, entering the valley at Glendive. Dawson County, which included all of the Plains area prior to 1877, when Custer County was created, is mentioned in the United States census of 1880, but no statistics are recorded. The principal industry at this time was buffalo hunting; the hides were salted and shipped to eastern fur houses.

In Custer County, just west of this area, it is recorded (*3*) that cattle increased from 1,935 head in 1880 to more than 200,000 head in 1884. By 1886, 500,000 head were on the ranges. The winter of 1886–87 was very severe, and 60 percent of the livestock were said to have been lost because of lack of protection from cold and scarcity of feed.

Although eastern Montana always has been considered primarily a range country, practically all of the tillable lands were homesteaded and broken during the period of the so-called dry-land movement between the years 1907 and 1917. This resulted in the division of old counties and the creation of new ones.

Soon after Congress passed the Reclamation Act of 1902, surveys were made contemplating irrigation of the lands of the lower Yellowstone Valley in common with other projects in the State. Construction started in 1905. Water was first made available in 1909, and the system has been operated continuously since. Development was encouraged by the completion of branch railroads extending from Glendive and Snowden to Sidney.

No data are available on the production of crops throughout the area surveyed, but some indication of the trend of the agricultural development of the irrigated lands may be traced in the data for the lower Yellowstone (irrigation) project given in table 4.

TABLE 4.—*Acreage, production, yield, and value of important crops in the lower Yellowstone project, 1927–37* [1]

| Crop | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | Average yield 1927–37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sugar beets: | | | | | | | | | | | | |
| Acres | 3,439 | 4,987 | 5,911 | 7,402 | 10,002 | 9,095 | 11,544 | 12,081 | 13,536 | 12,275 | 12,331 | ---------- |
| Production ... tons | 34,102 | 39,506 | 57,859 | 91,907 | 109,731 | 118,340 | 150,518 | 137,182 | 158,071 | 124,627 | 151,305 | ---------- |
| Average yield ... do | 9.9 | 7.9 | 9.8 | 12.4 | 11.0 | 13.0 | 13.0 | 11.4 | 11.7 | 10.2 | 12.3 | 11.4 |
| Value of crop ... dollars | 249,031 | 288,959 | 405,013 | 665,555 | 658,386 | 532,530 | 839,890 | 740,783 | 1,144,434 | 980,814 | 756,525 | ---------- |
| Barley: | | | | | | | | | | | | |
| Acres | 1,365 | 2,250 | 2,846 | 3,827 | 3,813 | 3,945 | 2,784 | 2,295 | 1,326 | 1,331 | 1,613 | ---------- |
| Production ... bushels | 47,320 | 71,557 | 63,489 | 80,807 | 77,079 | 133,073 | 62,646 | 64,987 | 37,993 | 30,673 | 28,385 | ---------- |
| Average yield ... do | 34.7 | 31.8 | 22.3 | 21.1 | 20.2 | 33.7 | 22.5 | 28.3 | 28.7 | 23.0 | 17.6 | 25.5 |
| Value of crop ... dollars | 25,553 | 34,347 | 28,570 | 28,282 | 15,416 | 13,307 | 12,402 | 32,494 | 17,097 | 18,404 | 10,219 | ---------- |
| Wheat: | | | | | | | | | | | | |
| Acres | 3,064 | 4,044 | 3,280 | 2,042 | 878 | 1,955 | 2,252 | 2,355 | 4,702 | 4,256 | 5,260 | ---------- |
| Production ... bushels | 54,547 | 84,634 | 81,970 | 40,759 | 13,022 | 48,765 | 43,930 | 52,550 | 93,874 | 68,630 | 99,196 | ---------- |
| Average yield ... do | 17.8 | 20.9 | 25.0 | 20.0 | 14.8 | 24.9 | 19.5 | 22.3 | 20.0 | 16.1 | 18.9 | 20.0 |
| Value of crop ... dollars | 54,547 | 71,940 | 81,970 | 20,379 | 6,511 | 16,580 | 26,358 | 42,040 | 75,099 | 82,356 | 96,220 | ---------- |
| Oats: | | | | | | | | | | | | |
| Acres | 742 | 987 | 1,285 | 1,136 | 1,193 | 1,725 | 2,689 | 4,420 | 5,135 | 5,021 | 4,932 | ---------- |
| Production ... bushels | 26,857 | 26,781 | 52,051 | 30,721 | 31,981 | 59,991 | 88,322 | 191,565 | 209,802 | 151,855 | 90,992 | ---------- |
| Average yield ... do | 36.2 | 27.1 | 40.5 | 27.0 | 26.8 | 34.8 | 32.8 | 43.3 | 40.9 | 30.2 | 18.4 | 32.9 |
| Value of crop ... dollars | 8,594 | 8,570 | 20,820 | 10,752 | 4,797 | 3,600 | 13,248 | 76,626 | 73,430 | 72,890 | 18,198 | |
| Corn: | | | | | | | | | | | | |
| Acres | 347 | 121 | 748 | 749 | 1,522 | 2,373 | 1,540 | 1,317 | 570 | 1,120 | 1,486 | ---------- |
| Production ... bushels | 5,402 | 3,171 | 15,894 | 18,439 | 31,351 | 65,315 | 45,814 | 29,427 | 14,259 | 31,372 | 34,620 | ---------- |
| Average yield ... do | 15.6 | 26.2 | 21.2 | 24.6 | 20.6 | 27.5 | 29.7 | 22.3 | 25.0 | 28.0 | 23.3 | 24.8 |
| Value of crop ... dollars | 3,781 | 1,903 | 8,901 | 10,275 | 15,675 | 7,838 | 9,163 | 17,656 | 7,130 | 18,823 | 15,579 | ---------- |
| Rye: | | | | | | | | | | | | |
| Acres | ---------- | ---------- | 178 | 80 | 70 | 153 | ---------- | 14 | ---------- | ---------- | ---------- | ---------- |
| Production ... bushels | ---------- | ---------- | 3,235 | 1,403 | 1,490 | 6,313 | ---------- | 302 | ---------- | ---------- | ---------- | ---------- |
| Average yield ... do | ---------- | ---------- | 18.1 | 17.5 | 21.3 | 41.3 | ---------- | 21.6 | ---------- | ---------- | ---------- | 25.7 |
| Value of crop ... dollars | ---------- | ---------- | 1,426 | 421 | 298 | 442 | ---------- | 166 | ---------- | ---------- | ---------- | ---------- |
| Alfalfa hay: | | | | | | | | | | | | |
| Acres | 4,575 | 4,907 | 5,354 | 5,290 | 6,215 | 6,753 | 4,692 | 3,818 | 4,959 | 6,362 | 6,850 | ---------- |
| Production ... tons | 8,109 | 7,849 | 10,232 | 10,017 | 11,973 | 13,140 | 6,035 | 8,566 | 10,410 | 14,969 | 13,485 | ---------- |
| Average yield ... do | 1.8 | 1.6 | 1.9 | 1.9 | 1.9 | 1.9 | 1.3 | 2.2 | 2.1 | 2.4 | 2.0 | 1.9 |
| Value of crop ... dollars | 48,654 | 47,094 | 102,320 | 90,153 | 71,838 | 52,560 | 24,140 | 102,792 | 83,280 | 179,628 | 114,623 | ---------- |
| Other hay: | | | | | | | | | | | | |
| Acres | 216 | 437 | 658 | 1,122 | 1,828 | 1,198 | 3,341 | 1,787 | 1,263 | 4,585 | 1,770 | ---------- |
| Production ... tons | 361 | 469 | 906 | 1,609 | 1,651 | 1,490 | 3,711 | 2,070 | 3,046 | 6,197 | 1,971 | ---------- |
| Average yield ... do | 1.7 | 1.1 | 1.4 | 1.4 | 0.9 | 1.2 | 1.1 | 1.1 | 2.4 | 1.4 | 1.1 | 1.3 |
| Value of crop ... dollars | 1,295 | 1,407 | 3,950 | 5,414 | 4,953 | 2,980 | 7,422 | 10,088 | 8,750 | 37,182 | 9,855 | ---------- |

[1] Statistics furnished by U. S. Bureau of Reclamation.

TABLE 4.—*Acreage, production, yield, and value of important crops in the lower Yellowstone project, 1927–37*—Continued

| Crop | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | Average yield 1927–37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Corn fodder: | | | | | | | | | | | | |
| Acres | 60 | 290 | 279 | 359 | 459 | 693 | 1,091 | 3,587 | 3,176 | 3,642 | 5,423 | ---------- |
| Production, tons | 139 | ---------- | ---------- | 452 | 664 | 1,570 | 3,091 | 8,121 | 5,865 | 5,496 | 8,953 | ---------- |
| Average yield, do | 2.3 | ---------- | ---------- | 1.3 | 1.4 | 2.3 | 2 8 | 2.3 | 1.8 | 1.5 | 1.7 | 1.9 |
| Value of crop, dollars | 417 | 2,030 | 3,070 | 904 | 997 | 3,140 | 6,182 | 48,726 | 29,325 | 54,960 | 49,242 | ---------- |
| Other forage: | | | | | | | | | | | | |
| Acres | ---------- | ---------- | ---------- | ---------- | 137 | ---------- | 11,667 | 12,714 | 13,536 | 13,420 | 12,398 | ---------- |
| Production, tons | ---------- | ---------- | ---------- | ---------- | 216 | ---------- | 11,820 | ---------- | ---------- | 13,034 | ---------- | ---------- |
| Average yield, do | ---------- | ---------- | ---------- | ---------- | 1.6 | ---------- | 1.0 | ---------- | ---------- | 1.0 | ---------- | ---------- |
| Value of crop, dollars | ---------- | ---------- | 14,777 | ---------- | 25,653 | 9,095 | 30,656 | 42,663 | 40,608 | 39.010 | 35,715 | ---------- |
| Pasture: | | | | | | | | | | | | |
| Acres | 402 | 801 | 1,678 | 2,065 | 1,963 | 1,579 | 1,895 | 1,845 | 1,361 | 1,945 | 2,432 | ---------- |
| Value, dollars | 2,151 | 3,729 | 6,414 | 7,874 | 6,048 | 5,898 | 3,487 | 4,992 | 2,216 | 5,925 | 5,122 | ---------- |
| Beans: | | | | | | | | | | | | |
| Acres | 870 | 509 | 1,062 | 1,891 | 2,109 | 444 | 1,027 | 685 | 550 | 454 | 948 | ---------- |
| Production, bushels | 3,343 | 9,724 | 15.540 | 25,827 | 18,764 | 5,013 | 20,264 | 9,187 | 10,475 | 8,752 | 17,729 | ---------- |
| Average yield, do | 3.8 | 19.1 | 14.6 | 13.7 | 8.9 | 11.3 | 19.7 | 13.4 | 19.0 | 19.3 | 18.7 | 13.7 |
| Value of crop, dollars | 6,352 | 29,172 | 51,282 | 46,489 | 17,208 | 2,607 | 18,238 | 11,024 | 8,094 | 21,005 | 21,275 | ---------- |
| Potatoes: | | | | | | | | | | | | |
| Acres | 96 | 90 | 194 | 187 | 308 | 428 | 285 | 613 | 609 | 621 | 503 | ---------- |
| Production, bushels | 17,370 | 13,433 | 24,503 | 31,053 | 44,230 | 52,302 | 39,816 | 55,171 | 72,833 | 66,548 | 66,961 | ---------- |
| Average yield, do | 180.9 | 149.3 | 126.3 | 166.1 | 143 6 | 122.2 | 139.7 | 90.0 | 119.6 | 107.2 | 133.1 | 123.3 |
| Value of crop, dollars | 4,343 | 1,343 | 36,756 | 31,053 | 8,846 | ---------- | 15,926 | 27,586 | 29,133 | 59,893 | 23.436 | ---------- |
| Truck and garden crops: | | | | | | | | | | | | |
| Acres | 155 | 96 | 186 | 153 | 228 | 315 | 309 | 323 | 351 | 371 | 375 | ---------- |
| Value of crop, dollars | 10,006 | 5,705 | 7,588 | 12,408 | 15,907 | 13,019 | 20,345 | 19,785 | 21,580 | 27,711 | 21,710 | ---------- |

The table showing the acreages and crop yields for the lower Yellowstone project indicate that in acreage and also cash return per acre sugar beets rank first among the crops on the irrigated lands. Of the 44,251 acres irrigated in this project in 1937, sugar beets occupied 12,331 acres, or about 28 percent, although generally the acreage handled by the individual farmer is small—from 5 to 20 acres.

Wheat is the second leading cash crop. About 12 percent of the irrigated land in the lower Yellowstone project was devoted to this crop in 1937. It is grown in the ordinary rotation, generally following an intertilled crop, such as corn, sugar beets, or beans.

Alfalfa must be regarded as the fundamental crop for the irrigation project. It is the foundation of practically all systems of farming adapted to the project. In 1937 alfalfa occupied about 16 percent of the irrigated acreage. As an aid in the maintenance of soil fertility, as well as providing additional hay for livestock-feeding operations, the acreage of alfalfa could be increased to equal that of sugar beets. The production of alfalfa seed has had a very minor place in the agricultural program.' Sweetclover, mainly for pasture, occupies a small acreage.

The acreage of corn varies considerably from year to year, but it is considered one of the surest and best-yielding feed crops. Corn does best on the medium- to light-textured soils that warm earlier in the spring and afford a longer growing season than the heavier-textured soils. A few farmers specialize in growing corn for seed.

The production of barley reached its peak in 1932, after which it declined. It seems to be better adapted to the heavy soils than is corn. Oats are replacing barley in recent years on the irrigation project and now are grown as extensively as wheat.

Beans are grown with considerable success in the irrigated areas. This crop fits well in the alfalfa-sugar beet rotations as an intermediate crop. Most farmers provide a small area near the homestead for the production of small fruits and garden vegetables, such as potatoes, onions, cabbage, sweet corn, cantaloups, watermelons, cucumbers, carrots, turnips, and tomatoes, all of which can be produced successfully under irrigation.

In addition to the lower Yellowstone project, which extends from Intake in Dawson County through parts of Richland County and McKenzie County, N. Dak., private irrigation systems are located near the mouths of Deer and Cabin Creeks. These last-mentioned areas include about 1,000 acres and are used for the production of alfalfa and native hay. Other tracts may be irrigated by the use of floodwaters from tributary streams or by pumping directly from Yellowstone River.

Dry farming prevails in the area above or west of the main canal, between Benz and Intake in the valley, and on valley slopes bordering Yellowstone River.

From the census data it is impossible to determine the acreage in crops in a particular part of any one county, and it is not possible to isolate the irrigated acreage from the dry-farmed acreage. During the progress of the soil survey in 1931 and 1932, it was estimated by the surveyors that approximately 30,000 acres of land lying above the main canal, in the valley, and on the valley slopes were used in

128330—39——2

the production of grain crops, mainly spring wheat. The rest of the dry land either was idle or was used only for grazing.

Until very recently the use of soil amendments other than barnyard manure has been practically unknown. Now, commercial fertilizers are applied to sugar beets, because the sugar company advises their use. Superphosphate is the principal fertilizer used.

During the last few years, labor has been plentiful, even during the harvesting season. Formerly, much of the labor performed in the production of sugar beets was by persons who came into the area for the season; now, it is provided largely by residents.

The size of farms varies considerably, depending on the type of farming carried on, whether dry or irrigated, and on the tillable acreage or the topography of the land concerned. In the irrigated districts of the lower Yellowstone project, the size of the units ranges from 40 to 160 acres, depending somewhat on the irrigable acreage. In the dry-farming sections, the farms range from a quarter section to several sections in size, varying according to the tillable area and the type of farming. Since the introduction of power machinery the number of farms has decreased, and there has been a consequent increase in size. Although no data are applicable to this area alone, some idea of the trend in number, size, and tenure of farms during the last 10 years may be gained from corresponding data collected by the United States Bureau of the Census for Prairie, Dawson, and Richland Counties, presented in table 5.

TABLE 5.—*Number, average size, and tenure of farms in Prairie, Dawson, and Richland Counties, Mont., in stated years*

| County and year | Number | Average size | Operated by— | | |
|---|---|---|---|---|---|
| | | | Owners | Tenants | Managers |
| Prairie: | | *Acres* | *Percent* | *Percent* | *Percent* |
| 1920 | 673 | 815.7 | 90.2 | 8.9 | 0.9 |
| 1930 | 559 | 1,291.9 | 75.7 | 24.0 | .3 |
| 1935 | 539 | 1,278.0 | 72.9 | 27.1 | .0 |
| Dawson: | | | | | |
| 1920 | 1,195 | 625.9 | 85.4 | 13.6 | 1.0 |
| 1930 | 1,018 | 1,042.4 | 71.1 | 28.3 | .6 |
| 1935 | 1,017 | 960.4 | 67.4 | 32.4 | .2 |
| Richland: | | | | | |
| 1920 | 1,577 | 515.0 | 87.1 | 12.0 | .9 |
| 1930 | 1,341 | 675.4 | 72.1 | 27.4 | .5 |
| 1935 | 1,506 | 583.0 | 67.7 | 32.1 | .2 |

Of the 605 farms in the lower Yellowstone project, 381 were operated by owners and 224 by tenants in 1937.

Although a few fine modern farm dwellings and other farm buildings have been erected in the area, many of the buildings consist of rather plain dwellings and sheds. Most farmers have practically all types of modern machinery suited to either dry farming or irrigation farming as their land demands. Since the introduction of the tractor the number of horses has been reduced considerably.

In 1937 the census of the Bureau of Reclamation reports a total value of irrigated crops in the lower Yellowstone project of $1,322,430 compared with a total value of $911,522 for livestock. The number and value of the several kinds of livestock are given in table 6.

TABLE 6.—*Number and value of livestock in the lower Yellowstone project, Montana-North Dakota, in 1937* [1]

| Livestock | Number | Value | Livestock | Number | Value |
|---|---|---|---|---|---|
| Cattle: | | | | | |
| Beef | 1,608 | $57,595 | Horses and mules | 1,578 | $84,608 |
| Range feeders | 4,013 | 140,337 | Swine | 1,871 | 17,127 |
| Dairy | 1,784 | 66,909 | Poultry | 21,176 | 13,116 |
| Sheep | 108,983 | 530,115 | Bees (hives) | 276 | 1,715 |

[1] Statistics furnished by U. S. Bureau of Reclamation.

All eastern Montana has been considered primarily a range country. In the early days large cattle outfits controlled the territory. Cattle did not share the range with sheep for a number of years. With the coming of the dry-land farmers, most of the large livestock companies gradually dissolved, and their holdings were replaced by many smaller livestock ranches and grain farms.

At present sheep far outnumber cattle and are the most important class of livestock. Sheep are kept on most farms. Since the establishment of the beet-sugar factory at Sidney, which has beet pulp as a byproduct, the feeding of lambs has become an important enterprise on the irrigation project. Feeder lambs are driven direct from the range to feed lots soon after the beet harvest. It has been estimated by the county agent that in 1930 there were about 20,500 lambs being fed on farms within the project area. This number reached a peak of about 135,000 in 1936, but in 1938 the estimated number had decreased to 115,000. Each year a few owners bring their sheep into the valley for wintering, because of the availability of feed supplies produced in the irrigated areas.

The first settlers engaged in cattle ranching, and large herds of cattle were trailed over the prairies. Most of the cattle are marketed as feeders which are finished in the Middle West. It has been estimated that from 800 to 1,000 head of cattle are fed and fattened in the Sidney territory each year.

Hogs are common on most of the irrigated farms. There has been a steady increase in number in recent years. The principal hog feeds are wheat, barley, or corn supplemented with skim milk and pasture.

Dairying has been of little commercial importance in years past, but the number of dairy cattle is increasing, particularly on the irrigated lands, where large quantities of alfalfa and feed grains can be produced. The natural resources are excellent, but the distance of the area from large consuming centers limits the market for dairy products.

Practically all farms maintain a flock of poultry for supplying the farmer's family with poultry and eggs. Any surplus is used in trade for groceries.

## SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of

distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil[2] and its content of lime and salts are determined by simple tests.[3] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land such as coastal beach or bare rocky mountainsides that have no true soil are called (4) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Consequently, some of the series names come from other areas. This system of naming the soil series is designed to eliminate the adoption of unnecessary new names and prevents the application of more than one name to identical soils in different areas. Havre, Harlem, Banks, and Bowdoin are names of important soil series in this area.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Havre very fine sandy loam and Havre silt loam are soil types within the Havre series represented in this area. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type there may be areas

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[2] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[3] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

## SOILS AND CROPS

The survey of the lower Yellowstone Valley area was largely concerned with the valley bottoms, benches, and slopes of Yellowstone Valley, which are adjacent to or lower than irrigation canals. Some of the bordering uplands and slopes were included in this survey to make the area more or less continuous and regular. The irrigation project area may be considered a section of diversified farming when compared with other parts of the State. This irrigated area has advantages over others in the variety of crops that it is possible to grow because of low altitude, length of growing season, and other climatic factors, as well as the moisture supplied through irrigation.

The cropping practices of the area depend to a large extent on the location, or the lay of the land, which determines its irrigability and drainage, as well as on the character of the soils. The dry-farmed soils of the valley and also the uplands are limited to the production of crops that withstand drought well, such as grains and native grasses.

The smooth nonirrigated soils of the upland have developed distinct soil layers, or horizons. The subsoil generally is heavier, and the moisture-holding capacity, response to summer fallowing, and yields of spring wheat are better on these upland benches than on the younger nonirrigated soils of the valley slopes or valley bottoms. The latter have not had sufficient time to develop distinct layers, and, unless the soil material is very heavy, they are porous from the surface downward through the subsoil. For this reason the valley bottoms and slopes, unless subirrigated or subject to seepage from higher lands, are not so well adapted to dry farming as are the older soils on the benches and uplands. The porosity of the soils of the valley bottoms and slopes, on the other hand, is a favorable factor under irrigation, since it allows excellent drainage, thus avoiding to a large extent the problems of seepage and alkali generally associated with irrigation.

On the bases of topography, accessibility, and adaptability for irrigation purposes, the soils of the area may be divided roughly into five groups, namely: (1) Soils of the valley bottoms, (2) soils of the valley benches, (3) soils of the valley slopes, (4) soils of the upland, and (5) miscellaneous soils and land types.

In subsequent pages of this report the soils of the lower Yellowstone Valley area are described in detail and their locations are indicated on the soil map. The soils are discussed in relation to their limitations and their adaptation for the production of the various crops suited to the section. Their acreage and proportionate extent are presented in table 7.

TABLE 7.—*Acreage and proportionate extent of the soils mapped in the lower Yellowstone Valley area, Montana*

| Soil type | Acres | Percent | Soil type | Acres | Percent |
|---|---|---|---|---|---|
| Havre silt loam | 13,824 | 5.2 | Moline clay loam | 1,344 | 1.0 |
| Havre silty clay loam | 5,056 | 1.9 | Patent silty clay loam | 3,008 | 1.1 |
| Havre very fine sandy loam | 17,600 | 6.6 | Patent silt loam | 1,472 | 1.0 |
| Harlem clay | 384 | (1) | Cherry silt loam | 23,680 | 8.9 |
| Banks loamy fine sand | 16,192 | 6.1 | Cherry silt loam, shallow phase | 2,176 | 1.0 |
| Banks very fine sandy loam | 4,480 | 1.6 | Cherry silty clay loam | 1,920 | 1.0 |
| Bowdoin clay | 3,840 | 1.4 | Beaverton fine sandy loam, slope phase | 6,400 | 2.4 |
| Laurel loam | 1,664 | 1.0 | Williams loam | 7,296 | 2.7 |
| Cheyenne loam | 7,104 | 2.7 | Williams fine sandy loam | 4,864 | 1.8 |
| Cheyenne fine sandy loam | 22,784 | 8.6 | Williams gravelly loam | 9,344 | 3.5 |
| Beaverton loam | 1,792 | 1.0 | Rough broken land | 59,328 | 22.5 |
| Beaverton fine sandy loam | 6,144 | 2.3 | Colluvial soils, undifferentiated | 2,752 | 1.0 |
| Farland silt loam | 448 | (1) | Alluvial soils, undifferentiated | 384 | (1) |
| Farland loam | 960 | (1) | Riverwash | 22,976 | 8.7 |
| Farland silty clay loam | 128 | (1) | | | |
| Savage silt loam | 6,784 | 2.5 | Total | 263,680 | ----- |
| Savage silty clay | 896 | (1) | | | |
| McKenzie clay loam | 6,656 | 2.5 | | | |

[1] Less than 0.1 percent.

## SOILS OF THE VALLEY BOTTOMS

The soils of the valley bottoms, because of their location, are important both as regards irrigability and the production of crops. The soils of this group are members of the Havre, Harlem, Bowdoin, Banks, and Laurel series. The Havre soils make up the greatest aggregate area in this section and are the most important agriculturally.

The Havre soils of the lower Yellowstone Valley area are young and have not accumulated much organic matter. They require a rotation which includes a legume crop in order to build up and maintain the nitrogen content. Most of the crops adapted to this area may be arranged in a suitable rotation to meet these requirements. From the point of view of ease of management, durability, and productivity, Havre silt loam is probably the most desirable Havre soil. Its organic-matter content is comparatively higher than that of the other Havre soils, and its moisture-holding capacity is fairly high despite the porosity of the soil material.

The Harlem soils are called gumbo soils, but they have rather light textured subsoils which allow free internal drainage. Alfalfa, bluejoint, and small grains are the principal crops.

The Banks soils are the youngest immature soils in the valley bottoms. They occur adjacent to Yellowstone River and on the islands of the river. They consist of a very thin layer of soil developed over incoherent sands and gravels. Owing to the coarse porous substratum, internal drainage is excessive. Only a small acreage of these soils is farmed, because cultivation must be preceded by much leveling, natural fertility is rather low, and large quantities of irrigation water are necessary. As the Banks soils contain little organic

matter, they require a rotation including legumes in order that the nitrogen content may be increased. Most of these soils at present are utilized for the virgin pasturage they afford. Trees or brush generally form the cover, and numerous high-water channels dissect the land. Dry farming is not attempted on these soils because of their droughtiness.

Like the Harlem soils, the Bowdoin soils, which are largely clay in texture, are locally known as gumbo soils, but they differ from the Harlem soils in having lighter colored surface soils and heavier textured subsoils. Their heavy texture and the generally low position with respect to the surrounding land impede both surface and internal drainage. They are therefore less desirable than other soils of the area. The crops that may be satisfactorily grown on these soils are largely limited to hay and grain.

The Laurel soils occur only on the bottoms of the smaller streams that drain the bordering uplands. They are not irrigated except by flooding during the spring run-off. In places, poorly drained areas have accumulated considerable salts. These soils are used largely for hay or pasture.

**Havre silt loam.**—Havre silt loam probably is the most important irrigated soil of the valley bottoms. Numerous areas are scattered all along Yellowstone Valley, particularly the wide parts, as between Savage and Ridgelawn.

The surface soil ranges from grayish brown to brown and from mellow silt loam to heavy silt loam. The darker color is generally associated with the heavier texture. In most of the undisturbed areas, a slight mulch of very fine sandy loam overlies the surface soil. A very faint prismatic structure appears in the lower part of the surface soil. In most places the soil is calcareous at or near the surface. The thickness of the silty surface material varies greatly but averages about 11 inches. The subsoil is light-gray very fine sandy loam or very fine sand, in general calcareous. Lime is well distributed throughout the soil, and there is no evidence of its concentration. Incoherent sands or gravels are reached at a depth ranging from 2 to 3 feet.

This soil is easily cultivated. There are no stones to interfere with plowing or the cultivation of crops, and the silty texture and friable consistence allow the surface moisture to percolate readily to the lower depths. The land warms early in the spring and may be cultivated sooner after rains than the heavier textured soils.

Certain areas of this soil have become affected by an accumulation of salts, in most places due to seepage from a canal situated above this soil on the side of a steep break. The seepage caused a high water table, and, with the evaporation of the moisture at the surface, a concentration of salts resulted. Areas so affected are north of Savage, between that town and Hoffmanville, south of Crane, and north of Piche. Drainage ditches were installed, but not until considerable damage had already taken place. Reclamation of such areas is slow and difficult.

In areas where injurious quantities of salts are not present, this soil has an excellent physical character and is well suited to the growing of all crops common to the section. It is especially desirable for the production of sugar beets, beans, potatoes, and alfalfa. Rota-

tions are established around the most important crops of the section, sugar beets and alfalfa, according to the needs and desires of the individual farmer.

Although the organic-matter and nitrogen content is not high, this soil may be built up easily and quickly by applying barnyard manure and growing legumes. The use of superphosphate fertilizers for sugar beets and alfalfa increases yields considerably.

**Havre silty clay loam.**—Havre silty clay loam is the heaviest member of the Havre series mapped in this area and ranks as one of the medium-heavy soils of the valley. Small bodies of this soil are associated with Havre silt loam throughout the valley.

The color of the surface soil generally is somewhat darker than that of the lighter textured members of the Havre series, that is, brown or rather dark brown. The thickness of the surface soil, which is silty clay loam or, in places, silty clay, ranges from 6 to 20 inches. This layer tends to be very faintly prismatic, platy, and slightly calcareous. It is underlain by stratified silts and very fine sands, which continue to a depth ranging from 24 to 30 inches. The lower part of the subsoil is gray calcareous very fine sand. A poorly drained and saline area of this soil is situated north of Savage just under the main canal, from which considerable seepage takes place.

In places where Havre silty clay loam borders Bowdoin clay, its texure approaches a clay and the depth to the sandy substratum is greater. The position of this soil is somewhat lower than that of the lighter textured members of the Havre series, but for the most part it is somewhat higher than the basinlike areas of Bowdoin clay. Porosity, drainage, and other physical features are also somewhat more favorable than in that soil.

This soil is inherently very fertile and where fairly well drained produces excellent crops of alfalfa and sugar beets. High yields of barley and oats are obtained.

**Havre very fine sandy loam.**—Havre very fine sandy loam is similar in appearance and essential characteristics to Havre silt loam, with which it is associated, except that the surface soil contains a higher proportion of fine and very fine sand. Like other members of the Havre series, it is mildly calcareous. The 7- to 10-inch surface soil is grayish-brown very fine sandy loam of single-grain structure. The upper part of the subsoil, to a depth ranging from 20 to 30 inches, is coherent very fine sand or fine sand, which in places contains thin stratifications of silty material. The lower part of the subsoil is composed of rather loose incoherent sands and gravels.

This soil is suited to the production of the same crops as are grown on Havre silt loam, but it is not quite so productive as that soil unless it has been well manured and kept in legume crops part of the time. As the soil material is porous, moisture is not retained so well as in the heavier soils and more frequent irrigation is necessary. The nonirrigated areas are used either for the production of grain crops or for native pasture. This is an excellent soil, where it can be irrigated, for the production of potatoes and garden crops.

Havre very fine sandy loam is developed throughout the valley, in

most places bordering the river. On the town site and west of Sidney, a variation of this soil is mapped. Here, the soil occupies a fan-shaped position and is strongly influenced by coarse sandy alluvium transported by Lone Tree Creek, an upland drainageway. The material is very porous and contains much more coarse sandy particles than does the typical soil. At the present time, the stream channel of Lone Tree Creek has cut into the benchland leaving only sand and gravel, which is mapped as riverwash, in its immediate vicinity.

**Harlem clay.**—Harlem clay occupies a small area in T. 14 N., R. 54 E., near the mouth of Cabin Creek. The surface layer is somewhat darker colored than those of the Havre soils. It consists of dark-brown massive clay to an average depth of 15 inches. As in the Havre soils, the surface layer is underlain by lighter textured materials which, in this area, consist of fine or very fine sandy loam to a depth of several feet. The Harlem soil occurs in a bend of Yellowstone River. Incoming streams flood the land at intervals, but underdrainage rapidly removes the surplus water. The land is irrigated by a private system and is used for the production of alfalfa and bluejoint hay.

**Banks loamy fine sand.**—Banks loamy fine sand is a shallow immature soil, most areas of which are adjacent to the Yellowstone River or on its islands. The light grayish-brown surface soil is fine sand or very fine sand, in few places more than 3 inches thick. It contains but little organic matter and is weakly calcareous. The subsoil consists of gray loose very slightly calcareous fine sands which grade into sand or gravel below a depth of 12 inches.

Under proper management this soil produces fair yields of a variety of crops in the few places where it is farmed. A crop rotation containing some legume is required to improve and maintain the productivity of this soil. Response is made to phosphate and manure, and these amendments are commonly applied, especially when the land is planted to sugar beets. The soil is managed easily, but its natural fertility is low. As it is droughty, it requires more than normal quantities of irrigation water. It is rather expensive to bring this soil into production because its undulating surface requires much leveling before efficient irrigation is possible.

A variation of Banks loamy fine sand has certain features which give it a different value and land use. The soil is covered with trees or brush and is severely dissected by numerous high-water channels. The profile, however, is not essentially different from other areas of Banks loamy fine sand. To bring the soil of this variation into production, its forest cover must be removed and much leveling must be done. Present economic conditions, however, do not justify the expense of preparing it for production.

**Banks very fine sandy loam.**—Banks very fine sandy loam varies considerably in different parts of the area. It includes those well-drained soils of the river bottoms that have not accumulated so much organic matter as has Havre fine sandy loam. It differs from Banks loamy fine sand in having more clay and silt in its surface layer and a thicker layer of comparatively fine material over the loose sand and gravel. The surface soil is light grayish-brown fine

128330—39——3

sandy loam to an average depth of 12 inches. Below this is yellow very fine sand underlain, in some places, by coarser sand and gravel at a depth of 18 inches. In some small areas the subsoil is made up of alternate layers of sand and clay.

This soil occurs at the junction of the Yellowstone and Missouri Rivers and in an almost continuous strip, more than 10 miles long, on the western side of Yellowstone River. Smaller areas are farther up Yellowstone Valley.

The relief is slightly hummocky or billowy, and differences in relief may range from 2 to 10 feet within an area. Surface drainageways are not established; nevertheless, owing to the porous sandy subsoil, drainage is excessive in most places.

In its value for farming, Banks very fine sandy loam is slightly superior to Banks loamy fine sand. Much of it is covered by a fair to dense growth of brush. A part of the land is cleared and cultivated, and a small area is irrigated. The principal crops are small grains, yields of which are only fair in the best areas. Preparation of this soil for irrigation is expensive, and large quantities or water are required. The grazing value of the uncleared land is low, as the grasses make a sparse growth. A volunteer cover of sweetclover enhances the grazing value in a few places.

Several areas, especially those south of Intake, have a covering of trees or brush. In some places the trees, mainly cottonwood, are mature, whereas in others the original tree growth has been removed and has been replaced mainly by brush and shrubs.

**Bowdoin clay.**—Bowdoin clay is the heaviest and probably the most difficult soil to handle in this area. The largest bodies are in the northern part of the area near Nohly, Dore (N. Dak.), and Ridgelawn. Smaller areas are scattered throughout the valley.

As this soil is very immature, it has only a slight development of a profile. Along the State line east of Nohly, the surface soil is dark olive-gray massive calcareous clay, about 12 inches thick. The subsoil and substratum are gray intractable massive noncalcareous clay. In the northern and wider parts of the valley the soil is slightly darker and, in general, is freer of excessive quantities of salts than in some of the areas farther south, such as those near the Richland-Dawson County line. The areas affected with salts are somewhat lighter in color. In places, white crystals of salts are noticeable in the subsoil at a depth ranging from 18 to 24 inches.

Much of this land never has been cultivated. Many of the areas occupy basinlike depressions and act as natural reservoirs in the collection of any excess irrigation water, seepage, or natural rainfall. Their low position, together with the comparative impermeability of the soil, makes the land rather difficult to drain. The soil remains wet and cold long after the surrounding land is ready to be cultivated. Such areas are best suited to the production of bluejoint hay and pasture. The better drained areas produce fair yields of alfalfa, grain, and sugar beets.

Small areas having a silty clay texture are included with Bowdoin clay on the map. This soil is similar to typical Bowdoin clay, except that it is more friable, is somewhat better drained, and agriculturally is more desirable. Alfalfa and grain are the principal crops. Sugar beets do fairly well in certain of these included areas,

such as the one east of Fairview. Another variation is mapped in sec. 30, T. 24 N., R. 60 E., where a blanket, several inches thick, of light grayish-brown very fine sandy loam covers the deep clayey subsoil. This body occupies a basinlike position. Poor drainage and seepage are indicated by both soil and vegetation.

**Laurel loam.**—Laurel loam occurs along the smaller streams that serve as drainage outlets for the uplands north of Sidney, such as Four Mile, Hay, and Second Hay Creeks. The 6- to 9-inch surface soil is grayish-brown loam which is laminated at the immediate surface and nearly structureless below. The soil material is mildly calcareous. The subsoil is yellowish-brown calcareous compact silty clay loam which is somewhat massive and, below a depth of 24 or 26 inches, is streaked with white salts. Owing to the influence of local alluvium, this soil is somewhat variable in places.

This land is utilized largely for pasture and for the production of hay and some grain for feed. Certain areas have a heavy accumulation of white salts at the surface. The vegetation in such areas is almost wholly saltgrass, and the only value of the land is for the scant pasturage afforded.

## SOILS OF THE VALLEY BENCHES

The benches or terraces of Yellowstone Valley are former floors of old alluvial plains. As the river lowered its channel, new successive valley floors were established. The several benches rise above the valley floor from 10 to 250 feet. These benches are for the most part nearly level and have been subjected for so long a time to the soil-forming processes that, with the exception of the very heavy types, the soils have developed a rather distinct horizonation, or layering. The soils of the valley benches are classified with the Cheyenne, Beaverton, Farland, Savage, McKenzie, Moline, and Patent series.

The Cheyenne soils have a dark-brown color, a definite prismatic development in the layer that overlies a strong lime concentration, and a deep gravel horizon below the lime zone. Under irrigation, these soils produce good yields of any crops ordinarily grown in the valley. Some of the Cheyenne soils lie above the present level of irrigation and are utilized for the production of small grains and corn or for native pasture. Except for the color of the surface soil, the profiles of the Beaverton and Cheyenne soils are essentially the same. The Beaverton soils are lighter colored and do not extend so far down the valley as do the Cheyenne soils. The change in color is gradual, and at the actual point of junction, the difference is not visible. The Beaverton soils are characterized by a moderately dark grayish-brown surface soil, heavy subsurface layer, a concentrated lime zone, and a distinct gravel substratum. They are managed and used in the same manner as are the Cheyenne soils.

Throughout the upper layers the Farland soils resemble the Beaverton soils, but the gravelly substratum characteristic of the Beaverton either is lacking in the Farland soils or lies more than 4 feet below the surface. For the most part, the Farland soils are so situated that they are now used only in the production of small grains.

The Savage soils are darker colored than the other soils of the area. The texture is somewhat heavier than in either the Beaverton or the Farland soils, and the distinct layering of those soils is absent.

The stage of development of the Savage soils is intermediate between those of the mature and the young soils. They are productive under irrigation.

The McKenzie soils are dark-gray heavy intractable immature soils of the valley benches. These soils remain almost wholly in their native condition. The vegetal cover is sparse and consists chiefly of the plants more or less tolerant of alkali.

The Moline soils are even less mature and more saline than the McKenzie soils.

The Patent soils are dark gray and show little development of a profile. They are affected to some extent in spots by salts, as is shown by the dominance, in certain areas, of the alkali-tolerant plant known as *Atriplex argentea*. These soils remain largely in their native state and are used only for grazing.

**Cheyenne loam.**—Cheyenne loam is a very dark brown soil of the valley benches. It is mapped from the mouth of Yellowstone River to the vicinity of Glendive. Under virgin conditions, a brown sandy loam mulch about 2 inches thick lies on the surface. Below the mulch and extending to a depth ranging from 7 to 10 inches, is dark-brown friable weakly prismatic loam with a fair content of organic matter. The next lower layer of lighter grayish brown compact definitely prismatic noncalcareous loam overlies a strong lime zone, about 12 inches thick, which appears from 13 to 16 inches below the surface. The heavy concentration of lime carbonates gives the layer a gray color and a friable condition. Alternating layers of gravel and sand underlie the lime zone.

In an area north of Fairview, the lime zone is not so concentrated as elsewhere and the gravel substratum is somewhat mottled with brown iron stains. The latter condition is indicative of former deficient drainage.

Cheyenne loam, one of the better soils of the valley, is fertile and friable. Agriculturally it is similar to Williams loam as mapped in the glaciated uplands. Yields are low in only a few areas where the subsoil gravel is close to the surface. For the most part the irrigated land is utilized by rotating alfalfa with sugar beets and grain crops. Seed corn is produced near Crane. Dry-farmed areas are devoted largely to the production of wheat.

**Cheyenne fine sandy loam.**—The greater part of Cheyenne fine sandy loam mapped in this area, including some of the largest bodies, differs in some respects from Cheyenne fine sandy loam as developed elsewhere. The finer soil is thicker than that of typical Cheyenne soils, and the substratum consists of fine sand or fine sandy loam instead of gravel. The surface layer to a depth of 3 or 4 inches consists of laminated grayish-brown fine sandy loam. Below this and continuing to a depth of 12 inches the soil material is dark grayish-brown granular fine sandy loam. The next lower layer consists of light olive-brown mildly calcareous very fine sandy loam which gives way to grayish-yellow strongly calcareous silt loam or very fine sandy loam. Gray calcareous sand underlies this soil at a depth ranging from 24 to 48 inches.

In numerous small areas over the northern part of the valley, especially around and south of Savage, are bodies of Cheyenne fine sandy loam which are considered mere representative of this soil as mapped

in other parts of the country. The surface layer of these scattered bodies of Cheyenne fine sandy loam is the common surface mulch of the section, consisting of a 1- to 2-inch layer of dark grayish-brown silty loam or very fine sandy loam. Below this and continuing to a depth ranging from 7 to 10 inches is dark grayish-brown fine sandy loam. A weak prismatic structure is apparent in most places. The next lower layer is brown fine sandy loam or loam. The 12-inch layer of lime accumulation is reached in most places at a depth of 18 inches. The texture is the same as in the layer above. Below the lime zone are loose gravel or alternating beds of sand and gravel, which continue to a depth of many feet.

For the most part the soil is free from injurious quantities of salts, but in the vicinity of Terry some areas show an accumulation of salts, caused by seepage of drainage waters from higher land. In places where Cheyenne fine sandy loam borders the Cherry soils, its layers, particularly the lime horizon, are less distinct.

Areas of Cheyenne fine sandy loam are porous and well drained. Small grains, potatoes, sugar beets, beans, and alfalfa do well. The deeper soil has physical properties that are excellently adapted to farming under irrigation, but most of the land is so situated that it cannot be irrigated at present. The area in which the village of Dore is located, and several areas on the west side of Yellowstone River, are farmed very successfully under irrigation. All the crops grown in the irrigated part of the valley return good yields. The large bodies of this soil on the eastern side of Yellowstone River, and a part of that on the western side, lie above the irrigation ditches. Under dry farming, these areas produce as well as the better class of upland soils, except where the soil is comparatively shallow, as in such places the sandy and gravelly substratum does not favor the retention of moisture. Wheat and corn are the principal crops grown without irrigation.

**Beaverton loam.**—Beaverton loam is a dark grayish-brown soil that is well scattered along the benches of the river valley southwest of Glendive. Under irrigation, it is productive except in some small areas where the gravelly subsoil lies near the surface. In undisturbed areas, the surface is covered by a 2- or 3-inch moderately dark grayish-brown very fine sandy loam mulch. The underlying soil material is about 12 inches thick and consists of rich dark-brown prismatic noncalcareous loam. Below this is a distinctly concentrated lime zone ranging from 8 to 12 inches in thickness. The large quantity of lime imparts a light-gray color to the very fine sandy subsoil. The substratum comprises distinct layers of gravel and sand. The depth from the surface downward to this gravel layer is variable.

Beaverton loam is one of the more desirable soils of the valley. It is productive, well drained, and friable—all favorable qualities in irrigated land. Under irrigation and proper management this soil will produce good yields of any of the crops ordinarily suited to the area, such as alfalfa, small grains, corn, potatoes, and beans. Wheat is the principal crop when the land is dry-farmed.

**Beaverton fine sandy loam.**—Beaverton fine sandy loam is very similar to Beaverton loam, with which it is associated in many places, but, owing to a higher percentage of sand particles, the texture of the surface soil is somewhat coarser. The prismatic structure of the sub-

surface layer is not so distinct and the lime layer ordinarily is at a slightly greater depth than in the heavier loam soil. Beaverton fine sandy loam occurs in numerous bodies throughout the valley southwest of Glendive.

This land possesses an excellent physical structure for farming under irrigation, as the moisture can be controlled to a large extent. For cropping under irrigation, however, the low nitrogen content must be built up by applying manures and by growing legumes. Alfalfa, sugar beets, potatoes, corn, and beans grow well on this soil.

This soil is not so well suited for dry farming as are the heavier loam soils, because of its somewhat smaller moisture-holding capacity. Also, where the gravel stratum approaches the surface, the moisture-holding capacity of the soil is further reduced, as the benefit from moisture storage derived from summer fallowing depends to a great extent on the depth of the soil material that overlies the gravel layer as well as on the texture of the surface soil and subsurface soil. Wheat and corn are the principal crops grown in the dry-farmed areas. The native vegetation of the unbroken areas consists of grama grass, junegrass, threadleaf sedge (niggerwool), and small sagebrush.

**Farland silt loam.**—Farland silt loam is developed along and east of the Montana-North Dakota State line. The topmost 4- or 5-inch layer is dark grayish-brown friable silt loam. It is underlain by a 4- or 6-inch layer of generally noncalcareous material that has a poorly defined nut structure. Below this, the soil grades into light grayish-brown mellow almost structureless loam or silt loam. Gravel and other material that impede drainage are absent, at least within significant depths.

Farland silt loam is an excellent soil. It is friable and free of salts. Drainage in most places is sufficient. Alfalfa, sugar beets, potatoes, small grains, corn, and beans yield well. The native vegetation consists chiefly of grama grass with smaller amounts of bluestem (western wheatgrass) and needle-and-thread (western needlegrass). The surface of Farland silt loam is smooth and level, a feature that favors inexpensive irrigation.

**Farland loam.**—A few areas of Farland loam are mapped east of Terry and south and east of Fallon. The soil is somewhat heavier and slightly darker colored in the topmost 8 or 10 inches than below. The texture varies from loam to silty clay loam, the latter predominating in places where this soil borders the Patent soils. Other characteristics of the profile are essentially similar to those of Farland silt loam. Where cultivated, wheat is the principal dry-land crop. Farland loam possesses the requisite qualities for a good irrigated soil.

**Farland silty clay loam.**—A few small areas of Farland silty clay loam are mapped in the northern part of the valley, on and near the Montana-North Dakota State line. The surface layer is dark grayish-brown friable silty clay loam, about 3 or 4 inches thick. This is underlain by a 4- or 6-inch layer of dark grayish-brown noncalcareous silty clay loam or silty clay. Below this the material becomes more friable and is strongly calcareous. The soil is sticky when wet and breaks into large clods when dry; therefore, it is not so easily cultivated as is Farland silt loam. Internal drainage is slow, and care must be taken in irrigating. In spite of these unfavorable characteristics, this soil is regarded as a good soil for irrigation, only slightly

lower in value than Farland silt loam. The crops commonly grown are those grown on the irrigated land. Sugar beets are especially well adapted to this soil.

**Savage silt loam.**—Savage silt loam is a dark-colored soil that occupies an intermediate position between the Cheyenne soils and the silty or gravelly slope material of the uplands. The main body of this soil extends from Ridgelawn to a point south of Sidney and roughly parallels the break of the uplands. Other areas are mapped near Newton, Fairview, and Savage and north of Hoyt. The dark color of this soil is caused by the moisture from seepage and the consequent heavier grass vegetation.

The 7- or 8-inch surface soil consists of very dark grayish-brown noncalcareous silt loam which is finely laminated at the immediate surface and granular below. The underlying layer is light grayish-brown mildly calcareous compact silty clay loam of no definite structure. The subsoil, between depths of 16 and 24 inches, is light olive-yellow strongly calcareous silty clay. To a depth of 48 inches the substratum is light olive-gray silt loam containing lenses of sand. Deep drainage ditches north of Sidney show a gravel layer 4 feet below the surface. Just east of Ridgelawn and in other small bodies, the soil is affected by salts, apparently due to seepage.

Except where affected by salts and poor drainage, this is considered one of the highly productive irrigated soils. Excellent yields of alfalfa, sugar beets, and grain are produced. Beans and corn are grown also, but these crops are somewhat better adapted, under the climatic conditions prevailing here, to the loam and fine sandy loam members of the Beaverton or Havre series. An area north of Sidney is cultivated on a rather intensive scale.

**Savage silty clay.**—Savage silty clay is of small extent, but the soil is distinct from the surrounding soils both in color and physical structure. The principal areas mapped are north of Hoyt and about 5 miles southwest of Glendive. The surface soil is very dark grayish-brown heavy silty clay or clay, that is very sticky when wet. The subsurface soil and subsoil are similar to the corresponding layers of Savage silt loam, except that they are heavier textured throughout. The silty clay is mildly calcareous within a few inches of the surface and becomes increasingly calcareous with depth.

This soil is not within reach of irrigation at present; therefore, much of it is used for the production of grain or remains in native-grass pasture. Its slow internal drainage and rather intractable character are unfavorable features for an irrigated soil, although certain soils with similar traits are being successfully farmed under irrigation. The natural fertility and surface drainage are satisfactory, and the relief offers no obstacle to irrigation. Drainage problems would be apt to appear more quickly in this soil than in other soils which possess greater porosity. Although this is a rather heavy soil for dry farming, high yields of grain are obtained in years when the rainfall is favorably distributed.

**McKenzie clay loam.**—McKenzie clay loam occupies benches or slopes bordering the low bottoms in the vicinity of Terry and westward. The surface soil, as examined in some detail near Terry, is dark olive-gray massive slightly calcareous silty clay loam or clay which ordinarily is in very poor physical condition. The next lower

layer, beginning at a depth of 5 or 6 inches, is olive-gray massive rather intractable clay. White mottlings of salts are common at a depth of 19 or 20 inches and become more concentrated downward. Lenses of fine sand are present in places below a depth of 40 inches. This soil appears to be developed from redeposited shale material.

The native vegetation on McKenzie clay loam consists largely of an alkaline-tolerant plant, known as *Atriplex argentea*, some scattered sagebrush, and bluestem. Much of this land remains in its native state, as efforts to dry-farm it have met with little success.

The value of this soil as irrigated land necessarily must be low because of its intractable character, slow internal drainage, and concentration of alkali. Artificial drainage, manures, legumes, and persistent as well as judicious management have been known to bring such soils slowly into satisfactory production. Chemical analyses made by the Montana Agricultural Experiment Station show considerable "black alkali," as well as "white alkali."

**Moline clay loam.**—Moline clay loam is a very shallow immature soil developed southwest of Glendive, over residual shale deposits which are a part of the Cedar Creek anticline. The surface layer, ranging from 2 to 6 inches in thickness, is moderately dark brown heavy loam which overlies gray massive saline clays. The clays are only slightly weathered and continue to undetermined depths. The numerous slick spots, that in some places make up 50 percent of the acreage, are depressed or lower than the general land surface. They are crusted with a light-gray deflocculated silty material containing considerable white salts.

Little use is made of this land other than for the scant grazing it affords. Its value under irrigation is rather questionable because the problems presented are similar and even more severe than those regarding McKenzie clay loam.

**Patent silty clay loam.**—The position of Patent silty clay loam is more favorable on the upper part of the valley bench which merges into the slopes adjoining the uplands than that of the McKenzie and Moline soils. This part of the bench is more sloping and, consequently, is better drained than the part occupied by those soils. Colluvial wash of coarser material is received in sufficient quantities to allow the development of a somewhat more porous friable soil. The 5- to 7-inch surface layer is brownish-gray faintly calcareous almost structureless fairly friable silty clay loam. Below this are gray massive clays which are sufficiently porous to allow moderate, though slow, drainage. The soil is free from alkali accumulations.

At present, the land is cultivated only in small areas where it may be irrigated by flooding. Under irrigation, Patent silty clay loam could be expected to return satisfactory yields of the small grains, legumes, potatoes, early-maturing corn, and sugar beets. Initial yields would not be high, but yields could be improved by a rotation including the growing of legumes and the application of manures. The smooth nearly flat surface would render irrigation not difficult. The native vegetation consists chiefly of wheatgrasses and sagebrush. *Atriplex argentea* grows in few places.

**Patent silt loam.**—Patent silt loam occurs in small bodies associated with Patent silty clay loam, mainly within a few miles of

Terry. Although this soil has the general characteristics of the Patent soils, the silty colluvial material washed down on the gentle slopes is thicker and the productivity is greater than is characteristic of the heavier members. The surface soil is variable but generally consists of at least 5 inches of olive-brown silt loam. This rests on a heavy clay subsoil, similar to that of Patent silty clay loam. This soil is used for the same purposes and to about the same extent as is Patent silty clay loam.

### SOILS OF THE VALLEY SLOPES

The soils of the valley slopes occupy an almost continuous strip along the upper borders of the valley on the slopes between the lower benches and the adjacent uplands. Layers are not distinct in these very young soils, little organic matter has been accumulated, and many of the characteristics of the colluvial parent materials are retained. These soils range from brown to moderately dark grayish brown and include the Cherry soils and the slope phase of Beaverton fine sandy loam.

**Cherry silt loam.**—The 7- to 10-inch surface soil of Cherry silt loam is grayish-brown or moderately dark grayish-brown smooth friable silt loam. In undisturbed areas, the layer is faintly laminated at the immediate surface and is almost structureless or massive below. The soil is mildly calcareous at or near the surface. This material is underlain to a depth of 22 inches by light yellowish-brown calcareous friable silty clay loam which is somewhat massive in structure. The lower part of the subsoil is light-olive or yellowish-gray friable silt or silty clay loam. This soil is developed over the colluvial wash that is derived from the gray and light grayish-brown beds of shale and sandstone of the Lance and Fort Union formations.

Although this soil is rather uniform over large areas, some variations occur. A few small bodies southwest of Fairview, west of Sidney, and south of Hoyt are more nearly very fine sandy loam in the surface soil and are slightly lighter textured throughout. A few nearly level areas of this soil are just southwest of Crackerbox Creek and on each side of Clear Creek. The relief of these areas is such that a greater degree of weathering has taken place, resulting in the leaching of the lime to a depth of 3 to 5 inches. Here, a slight concentration of the lime is noticeable. The surface soil is slightly darker and the subsoil more compact and heavier than elsewhere. Alkali accumulations are present in a few areas and are caused by seepage of moisture from higher levels. The largest body thus affected borders Bad Route Creek.

Areas of Cherry silt loam are scattered along the slopes between the level benches of the valley and the steep broken slopes or escarpment of the uplands from Dore, N. Dak., nearly to Fallon, mainly on the western side of the river valley. The largest bodies are between Fallon bridge and Sand Creek.

Excellent crops of alfalfa and sugar beets are produced on the irrigated land. The supply of organic matter is low but easily can be built up through legume crops and the application of manure. Internal drainage ranges from fair to rather slow. Small grains are grown in the nonirrigated areas, and very good yields of wheat are

obtained on well-prepared summer-fallowed land. Only in seasons of well-distributed rainfall, however, are good crops certain. The slope in most places is such that run-off is considerable, particularly during hard dashing rains.

**Cherry silt loam, shallow phase.**—The shallow phase is a more shallow immature soil than is typical Cherry silt loam. The surface layer which contains the organic matter is grayish-brown weakly calcareous silt loam, possesses little structure, and ranges from 2 to 4 inches in thickness. Below the surface layer are grayish-yellow massive unweathered clays or silty clays. The largest areas of this shallow soil are northwest of Fairview, where the former thinly glaciated surface material has washed away and the underlying shaly and sandstone material now is exposed.

Most of this land is used for grazing, although its relief would allow cultivation. Under irrigation its uses would be about the same as those of typical Cherry silt loam, but lower yields should be expected because of its shallowness and less desirable physical condition. Internal drainage is rather slow.

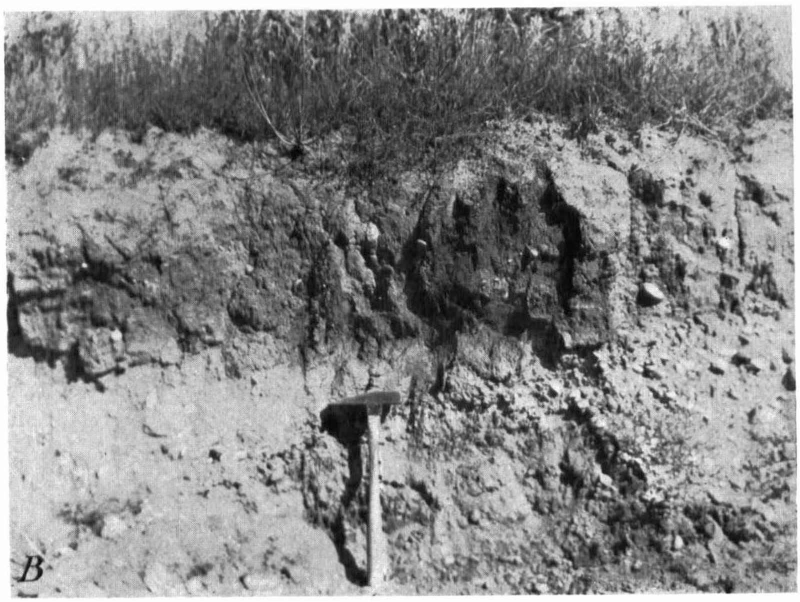
**Cherry silty clay loam.**—The 3- to 6-inch surface layer of Cherry silty clay loam consists of moderately dark grayish-brown to dark-gray weakly calcareous clay loam which has a massive structure. Yellowish-gray massive clays compose the underlying material. Lenses of very fine sand are numerous throughout the clays. The principal bodies of this soil are west of Glendive and east of Stipek.

The land is used almost entirely for grazing. If irrigated, a crop rotation including legumes should be introduced because of the low organic-matter content and rather poor physical condition. Surface drainage is rapid, but internal drainage is rather slow.

**Beaverton fine sandy loam, slope phase.**—Areas of Beaverton fine sandy loam that occupy slopes bordering the upland escarpment are separated as a slope phase. These areas occur mainly in the vicinity of Glendive and south of that town on the eastern side of the valley. To a depth of 5 inches the soil material is grayish-brown loose slightly calcareous fine sandy loam or very fine sandy loam. It is underlain, to a depth of about 24 inches, by light-gray calcareous very fine sand. Below this, the subsoil is light grayish-brown fine sand, which is only slightly calcareous and apparently developed from a light-colored sandstone member of the Lance formation, known as the Colgate sandstone.

Mapped with this phase of Beaverton fine sandy loam are areas in the vicinity of Terry and Fallon, in which the soil is somewhat darker and more mature, contains more organic matter, is noncalcareous nearer the surface, and has a better moisture-holding capacity than the soil developed south of Glendive. If irrigated, this included soil would be very productive.

Without irrigation, this soil is very droughty, as its physical structure and texture allow little storage of moisture for future crop use, and only in years of very favorable distribution of moisture can satisfactory crops be grown. Where irrigated, frequent applications of water are necessary during July and August. Legumes should be grown to increase the organic-matter content which is naturally low. This land is managed easily, is responsive to soil amendments, and, under irrigation, is suited to any of the common crops of the area.


*A*, Badlands, Fort Union formation, south of Savage; *B*, profile of Beaverton loam.

## SOILS OF THE UPLAND

The soils of the upland mapped in this area occur only in the glaciated section that borders the valley between Savage and Missouri River. The tillable soils are included in the Williams series. They cover an extensive area in the uplands of northern Montana and are considered well-developed or mature soils because of the distinct layers in their profiles.

**Williams loam.**—The undisturbed or virgin areas of Williams loam have a thin cover of grayish-brown loose mulch. The next layer, extending to a depth of 6 or 7 inches, is very dark grayish-brown loam that is somewhat laminated in the upper part and coarsely granular below. This material is underlain, to a depth of 15 or 16 inches, by brown heavy loam or silty clay loam, which is heavier and more compact than the material in the layers above and in most places has a prismatic structure. Fine gravel is scattered through the soil. The subsoil is yellowish-gray calcareous light-textured very friable silt loam streaked with carbonates.

The relief ranges from nearly level and gently sloping to rather billowy and hummocky. Glacial mounds, ridges, and depressions are common features of the landscape. The area of Williams soils in Richland County is the southern extension of the glaciated region, therefore the drift overlying the rocks of the Fort Union formation is thin, ranging from a few inches to several feet in depth. In the shallower drift-covered areas local material, consisting of yellow sandstones and shales, is exposed in many places.

Under careful tillage practices, such as maintaining a clean summer fallow at least once in 3 years, fairly good yields of wheat are obtained in normal seasons. Practically all of this land is broken.

The vegetation of the areas of the glacial upland not under cultivation consists chiefly of blue grama and associated grasses which provide excellent range forage. The area that is suited neither to irrigation nor to dry-land farming, together with the more gravelly rolling and broken land bordering Yellowstone Valley, is used almost entirely for grazing. Its proximity to the valley proper would allow a combination of livestock farming with more specialized irrigation farming under which winter feeds might be grown.

**Williams fine sandy loam.**—Williams fine sandy loam is developed extensively west of Fairview in association with the loam and gravelly loam members of the series. This soil is coarser and sandier than Williams loam, and because of this feature, drainage may be excessive. The soil layers are very similar to those described for Williams loam, but the texture is coarser throughout and the structure of the layer immediately overlying the lime zone is less distinctly prismatic than in the loam.

The organic-matter content and the water-holding capacity of the fine sandy loam are not so high as in the heavier loams, and the yields of small grain are not so good as on those soils. Soil drifting is likely to be a serious problem, once the fibrous roots are destroyed. Corn is grown to a larger extent on the sandy soils because they warm earlier in the season.

**Williams gravelly loam.**—Williams gravelly loam occurs throughout the more gently rolling glaciated uplands. Rough and broken areas are included in the land mapped as rough broken land. The soil ma-

terial is essentially the same as that composing Williams loam, but it is sandy in some places. The surface layer, which contains most of the organic matter, is shallower than the corresponding layer in the loam, and it contains considerable gravel ranging in size from pebbles to rocks several inches in diameter. In most places, the gravel content is sufficient to make plowing or cultivation difficult. This land is used largely for grazing.

### MISCELLANEOUS SOILS AND LAND TYPES

In this group are included various soil materials that are largely untillable.

**Rough broken land.**—This term is applied to all the broken and stony land of the glaciated area north of Savage, the escarpments that define Yellowstone Valley north of Savage, and the breaks that border streams entering the valley. In the glaciated area the hillsides and somewhat rounded knolls are covered with a deposit of stony and gravelly drift, with exposures of the underlying shales on the steeper slopes. A large proportion of the drift-covered areas support a grass vegetation and furnish more or less grazing. On slopes along the streams and the escarpment of Yellowstone Valley erosion has removed the dark-colored surface soil and exposed the unweathered yellow clays. In places the entire soil has been removed, and the shales and sandstones are exposed. Much of this land is bare of vegetation or supports a sparse growth of sagebrush, cacti, and coarse weeds and grasses. A few areas where erosion has been less active have a cover of grama and other nutritious grasses and provide good grazing. Rough broken land is not cultivated, and its average value for pasture is low. Some of the breaks, particularly south and east of Glendive and north of Terry, are typical badlands and are almost bare of vegetation.

**Colluvial soils, undifferentiated.**—The designation of colluvial soils, undifferentiated, is given to extremely variable, decidedly immature soils which originated from miscellaneous sands and gravels deposited by waters from the adjacent uplands and which have no definite profile. The material is coarse and very porous, and drainage is excessive. The position is ordinarily fanlike. Because of their droughtiness and lack of organic matter, dry farming is not feasible on these soils, and even under irrigation, their value would be low.

**Alluvial soils, undifferentiated.**—Alluvial soils, undifferentiated, include undeveloped poorly drained clays or loams, which occupy depressions and have little or no profile. The vegetation is either saltgrass or cattail. The areas are very small and scattered.

**Riverwash.**—As mapped along Yellowstone River and smaller stream courses, riverwash designates the unmodified incoherent gravels and sands, which form river bars or low tracts, that are periodically overrun by high waters. The material in most places is devoid of vegetation, but here and there it supports a scattered growth of brush or willows. It does not merit cultivation and at present is used only for the scant pasturage provided.

## LAND USES AND AGRICULTURAL METHODS

### WATER SUPPLY AND IRRIGATION [4]

The lower Yellowstone (irrigation) project requires no storage. The water supply is diverted directly from Yellowstone River by means of a low diversion dam at Intake. Construction of works for the delivery of water to the land is completed. A drainage system was begun in 1927 and was completed in 1931.

The main canal is 71.6 miles long, and there are approximately 210 miles of laterals. The capacity of the main canal is 830 feet per second at the head, and the grade is about 6 inches to the mile for the first 46 miles. Water is pumped to about 2,300 acres of land at Thomas Point just north of Savage by utilizing the energy of water dropped from the main canal to a lower lateral. The net lift is 31 feet. Of the 57,241 irrigable acres comprising the project in 1937, a small part lies in Dawson County, a little less than two-thirds in Richland County, and about one-third in McKenzie County, N. Dak.

Due to temporary deductions on account of seepage, brushland, and nonirrigable areas, the actual area cultivated and on which charges were assessed was 44,251 acres in 1937. Water was first made available in 1909, and the irrigation system has been operated each year since. The quantity of water delivered to farms in 1937 was 104,261 acre-feet. Water was available for a large part (31,234 acres) of the project area in 1931. The average value of the crops on irrigated land in 1937 was $29.88 per acre.

The upper Glendive-Fallon irrigation district, which was created in 1920, was intended to irrigate about 4,000 acres between Fallon and Glendive on the north side of the river. A steam pumping plant which burned lignite coal mined within a few rods of the plant was installed. Lack of complete settlement and financial difficulties has withheld any development of irrigation. For the most part the soils of the proposed area are suitable for irrigation, but some drainage would be necessary to eliminate seepage and alkali near the mouth of Bad Route Creek.

A private irrigation project is located near the mouth of Cabin Creek. This project provides only for diverting the natural flow of the creek during the spring when the flow is at its height.

Many areas bordering Yellowstone River have a soil and topography favorable for irrigation, but the installation of pumps is required to lift the water at heights ranging from 10 to 50 feet.

### AGRICULTURAL METHODS AND MANAGEMENT

The major part of the land now irrigated lies below the main canal of the lower Yellowstone project, which carries water diverted from Yellowstone River and supplies irrigation water throughout the growing season. Smaller streams, such as Deer and Cabin Creeks, supply water during only a part of the season, principally during the spring run-off, whereas the smaller streams generally supplement the natural rainfall to the extent of insuring at least

[4] Based on information supplied by H. A. Parker, formerly project manager, lower Yellowstone project, and statistics furnished by the U. S. Bureau of Reclamation.

one good cutting of hay. A dependable water supply throughout the growing season is necessary in order to obtain maximum yields of sugar beets and alfalfa.

In December 1927, an agricultural conference (*7*), considering primarily the irrigated land, was held in Sidney. This conference was composed of the leading farmers and businessmen and extension specialists from the Montana State College of Agriculture. The farm management committee of this conference stressed the importance of a proper system of production that would provide the necessary distribution of labor, maintain soil fertility, and take care of the weed problem. The committee report, based on experience in the valley, further recommended the following as a possible combination of crops that can be worked into a successful rotation for a farm of 80 acres or more; Alfalfa, grown on about 25 percent of the land; sugar beets, on 19 percent; barley or oats, on 10 percent; permanent pasture, on 8 percent; and sweetclover for hay or pasture, on 7 percent. The farmstead, roads, and ditches will take up about 8 percent of the land, leaving about 23 percent for such crops as corn, beans, and potatoes, the choice of which should depend on the individual needs of the farmer.

A study of the crop acreages, as reported by the Bureau of Reclamation for 1931, shows that sugar beets were actually grown on 32 percent of the irrigated acreage of the project; alfalfa, on 20 percent; barley, on 12 percent; corn, on 6 percent; beans, on 7 percent; oats, on 4 percent; pasture, on 6 percent; and such crops as wheat, potatoes, peas, flax, and garden crops on the remainder. In 1937, 28 percent of the irrigated land was devoted to sugar beets, 16 percent to corn (mostly fodder), 15 percent to alfalfa, 12 percent to wheat, 11 percent to oats, 5 percent to pasture, 4 percent to barley, 2 percent to beans, and the rest to miscellaneous crops.

Changes in price levels for the various crops account for the general trend of increase in the acreage in sugar beets at the expense of the acreage in alfalfa. From the point of view of maintenance of soil fertility, this change may be looked on with some misgiving unless it is accompanied by considerable use of fertilizers and the return of barnyard manures obtained through feeding operations. Alfalfa is an essential crop both as regards the production of feed and soil fertility.

In a series of rotation experiments, including sugar beets, conducted at the Huntley Experiment Station, Huntley, Mont., the following general results have been reported (*6*): The highest yields of sugar beets were obtained in rotations which included applications of manure, resulting in an average increase of 3.42 tons an acre, or in those which included 3 years of alfalfa, resulting in an average increase of 2.09 tons. Other rotations have shown a gradual decrease in yields. The application of manure in an alfalfa rotation increased the yield of beets an additional 2.34 tons, thus indicating the value of both practices. Greater returns were obtained when such crops as potatoes or oats were grown between alfalfa and sugar beets than when beets followed alfalfa directly. The yields of beets in all rotations were consistently higher following potatoes than after oats or wheat.

A rotation which has proved to be practical for most of the soils of the lower Yellowstone project is as follows: Alfalfa, 5 to 7 years; beans, corn, or potatoes, 1 year; sugar beets, 2 years; and barley, wheat, or oats, 1 year. The use of commercial fertilizers in maintaining or increasing yields of sugar beets has been encouraged recently by the sugar company, and results have been very good. Fertilizer tests during a period of 2 years on the irrigated lands throughout the State have shown that in a number of different areas and soils, good response, as indicated in increased yields, have been obtained by applying superphosphate (*4*, *5*) to such crops as alfalfa and sugar beets. Different results have been obtained for different soils, indicating the necessity of studying the response according to soil type.

The use of clean adapted seed in the growing of any crop cannot be overemphasized.[5] In general the medium-maturing grain varieties have done best on the irrigated land. Early-maturing varieties generally do best on the dry lands.

In the nonirrigated tillable areas the growing of wheat, oats, or barley probably will continue to be of importance from the point of view of feed production. If low prices continue, the production of grain as a cash crop will be comparatively unimportant.

According to the more recent experiences of the individual farmers, tillage practices, particularly the thoroughness and the regularity of summer fallowing, depend to considerable degree on the location and character of the various soil types. The benefits to be derived from the best summer-fallow practices on soils having the more open sandy or gravelly subsoils are small because of their inability to store much moisture. On the other hand, the chances of larger crops from good summer-fallow practices are much better on soils that have silty or silty clay subsoils. During the last few years, when the natural precipitation has been extremely low, the most precise cultural methods have not served to forestall a crop failure, particularly on the lighter textured soils. It has been shown in the better areas (*1*) that, as a rule, fallowed land produces larger yields of wheat with a higher protein content than land cropped continuously.

Depletion of nitrogen in the soil should be guarded against by growing leguminous crops and wherever possible returning all crop residues to the land. The application of nitrogenous commercial fertilizers is a further means of restoring or increasing the supply of nitrogen in the soil.

## MORPHOLOGY AND GENESIS OF SOILS

The factors of soil formation, as determined by the geographic environment, do not vary sufficiently over different parts of the lower Yellowstone Valley area to produce great differences in the soils. The area lies in the region of Chestnut soils. The mature soils of the well-drained uplands and benches are dark brown or very dark brown at the northern or lower end of the valley and slightly lighter colored at the southern or upper end.

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[5] Detailed recommendations regarding crop varieties may be obtained from the Agronomy Department, Montana Agricultural Experiment Station, Bozeman, Mont.

This area lies just west of the belt of Chernozem soils, which have attained the maximum blackness for well-drained soils. The moderately low rainfall in this area has been a controlling factor in preventing the accumulation of a large quantity of organic matter. Precipitation is insufficient to leach the soluble salts to as great a depth as in the region of Chernozem soils. As a result the soils in this area are grayish brown or very dark grayish brown, the humous layers are thinner, and the layer of lime accumulation is nearer the surface than in the Chernozem soils.

The principal differences in the soils of this area are due therefore to differences in the character of the parent materials. During the Pleistocene epoch, the northeastern part of the area was overrun by glaciers, and the surface was covered to various depths by glacial debris. Erosion has removed the glacial drift over part of the area. The rocks directly underlying the glacial drift consist of yellow beds of sandstone and shale of the Fort Union formation which contributes soil materials along the valley as far west as Terry. Most of the valley south and west of Savage never was covered with glacial drift, and the residual rocks are being eroded and weathered to form the soils (pl. 1, A). The lower, gray beds of the Fort Union formation, known as the Lebo shale member, outcrops at Terry. Near Glendive alternating beds of sandstone and shale of the Lance formation outcrop and overlie the Bearpaw shale. The latter formation contributes but little material for the formation of soil in this section. The sandstones contain considerable lime.

The survey of this area is concerned chiefly with the alluvial flood plains and the low terraces, as this is the land covered by irrigation projects. In order to cover all the alluvial lands the slopes and, in places, small parts of the smoother upland are included. Some of the upland and high-bench soils have been exposed to the soil-forming processes for a sufficient length of time to acquire the regional profile, but this profile does not exist in the low terraces and bottoms where the soil materials are comparatively very young. Where the alluvium consists of either gravel or heavy sediments, it has resisted the soil-forming agencies. Here and there, soluble salts strongly influence the character of the soil even at the surface. Lack of drainage has retarded development in certain places so that no real soil profile exists.

The soils that have attained an approximation of the regional profile occur on the comparatively small areas of smooth high benches which were capped in later Tertiary times. Undisturbed grassed-over areas are covered with a 1- or 2-inch grayish-brown loose mulch. The layer immediately below the mulch is brown and reaches a depth of 5 or 6 inches. It generally is laminated and somewhat granular in the upper part and cloddy or blocky in the lower part. Below this and continuing to a depth of 13 or 14 inches is a layer of brown prismatic compact material which is somewhat heavier in texture than the material above. As a rule, the zone of lime accumulation, which lies immediately below the compact prismatic layer, is fully 12 inches thick. The material is loose, structureless, very friable, and, owing to the heavy concentration of lime, light grayish brown. Below the lime zone is the parent material. The general description corresponds with the profiles of the Williams soils on the glaciated

uplands, the Cheyenne and Beaverton (pl. 1, B) soils on the well-drained terraces and benches and, to less extent, the Farland soils. The color at the surface is somewhat darker and the depth to the lime zone greater in the Cheyenne and Williams soils than the above description indicates. The Farland soils are not sufficiently mature to have attained a regional profile. The Savage soils are intrazonal as a result of poor drainage, although they are more developed than many other soils in the valley.

A majority of the soils in the area are intrazonal, and their characteristics are largely dominated by the parent material. Such soils are grouped in the Patent, McKenzie, Moline, and Cherry series. The Patent and McKenzie soils are dark gray and heavy textured. Their thin surface soils are underlain by heavy intractable clays. These soils may have salt accumulations in quantities sufficient to cause injury to vegetation. The Cherry soils are dominantly silty, calcareous, friable, and porous.

The soils of the flood plains of Yellowstone River are classed in four series, namely: Banks, Havre, Harlem, and Bowdoin. These soils owe their distinguishing characteristics mainly to the influence of their parent materials, since soil development has not advanced very far. The Banks soils have brown sandy surface soils, and their subsoils are loose incoherent sands. The moderately dark brown surface soils of the members of the Havre series range from very fine sandy loam to silty clay loam, and the subsoils from fine and very fine sand to very fine sandy loam. The Harlem soils have darker colored, heavier surface soils than do the Havre soils, but they have light-colored and light-textured subsoils. Dark-gray surface soils and dark olive-gray extremely heavy subsoils characterize the soils of the Bowdoin series.

The alluvial soils of the smaller streams draining the partly glaciated section are included in the Laurel series. They are calcareous, structureless, gray or brown loamy soils having heavy subsoils. The more poorly drained areas are saline.

## SUMMARY

The lower Yellowstone Valley area has a continental climate that is characterized by a moderately low annual precipitation, a dry atmosphere, hot summers, cold winters, and a large proportion of sunny days. For the production of diversified crops and maximum yields, irrigation is necessary to supplement the natural rainfall during summer. Small grains may be grown in most seasons under dry farming with careful management.

In general, the area which Yellowstone Valley dissects may be characterized as a rolling plain which slopes toward the north and east. A rather outstanding characteristic of the valley is the benches or terraces which border the alluvial bottoms. In places, a series of two or three benches rise above the present river valley.

Except where seepage occurs, the soils are naturally fairly well drained. With the development of irrigation and the construction of canals along steep-sided hills, considerable seepage and loss of water has occurred in areas where the soil materials consist of coarse sands and gravels. Some heavy low-lying soils have become natural reservoirs because of position. A well-planned system of drainage

ditches has been constructed. In most areas the ditches appear to be fairly efficient.

The survey was concerned primarily with the soils of the valley because the irrigated or potentially irrigable land borders the river.

The soils of the valley bottoms are, for the most part, well drained and porous, particularly the Havre soils. Under irrigation, these soils are adapted to diversified cropping. Although their natural content of organic matter is low, it is improved easily by growing legume crops and by returning manures and crop residues to the soil. The Bowdoin soils are restricted somewhat in crop adaptations because of their heavy texture and poor natural drainage. The other soils in this group are members of the Harlem, Banks, and Laurel series.

The well-developed or mature soils occupy the smooth remnants of the upland plain and the level terraces or benches that border the alluvial plain. These soils generally are better suited than the soils in the valley bottoms for dry-land farming, because their developed structure lends itself to the storage of moisture by good fallow methods. The dry-land farming of these soils, however, has met with very limited success. The bench-land soils that may be irrigated are well adapted to a diversified cropping system. These soils are members of the Savage, Cheyenne, Beaverton, and Farland series. The soils of the McKenzie, Moline, and Patent series are developing from heavy material that contains soluble salts and alkali salts. Their heavy character restricts utilization.

The soils of the valley slopes are comparatively young. They have a porous, almost structureless profile. The capacity of these soils for storage of moisture in the subsoil is less than in the well-developed soils, thus making them less favorably adapted to dry-land farming. This porous structure is desirable under irrigation, however, because the danger from seepage and salts is less. The Cherry soils are proving their adaptability to irrigation farming. The slope phase of Beaverton fine sandy loam consists of loose colluvial fine sands. This soil is not irrigated at present. It is less well adapted to dry farming than are the porous silty soils.

The soils of the upland are represented by three members of the Williams series.

The miscellaneous land types, which include rough broken land, riverwash, colluvial soils, undifferentiated, and alluvial soils, undifferentiated, are adapted only to grazing.

Diversified and intensive cropping in the lower Yellowstone Valley area depends on an adequate supply of irrigation water. The principal crops under irrigation are sugar beets and alfalfa. The growing of sugar beets has become increasingly popular because of the comparatively large returns per acre. This crop is best adapted to the porous well-drained light- to medium-textured soils. Heavy soils respond slowly until their physical structure is improved by the growth of legumes and the incorporation of organic matter. Although the soils of this area generally are rich in lime, they are naturally low in organic matter. Deficiency in phosphorus also is indicated by the response obtained when superphosphate is applied to the beet crop.

Dry farming is carried on in the areas not now irrigated but is limited generally to the production of small grains, with fallowing practiced in alternate years or only once in 3 years, depending on moisture conditions.

Livestock have an important part in the agricultural industry of the area. Bordering the Yellowstone Valley and throughout the area are large tracts of land unsuited for tillage purposes but well adapted to the grazing of livestock. Irrigation has made possible the extensive production of such crops as alfalfa, corn, and small grains. The expansion of the production of sugar beets and consequent development of the beet-sugar industry have produced large quantities of beet pulp. A plentiful supply of hay, grains, and beet pulp has encouraged considerable winter feeding of livestock.

The combination of feed crops, sugar beets, and livestock feeding has hastened the agricultural development of the area. Under this system, weeds are controlled fairly well, and the growth of legumes, the application of manures, and the practice of careful tillage have been beneficial to the soils.

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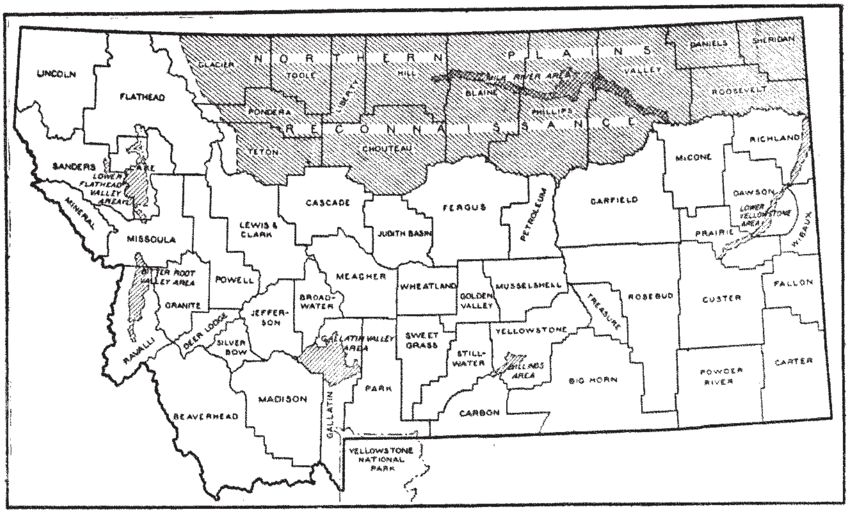

Areas surveyed in Montana, shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching.

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# SOIL MAP
LOWER YELLOWSTONE VALLEY AREA
MONTANA

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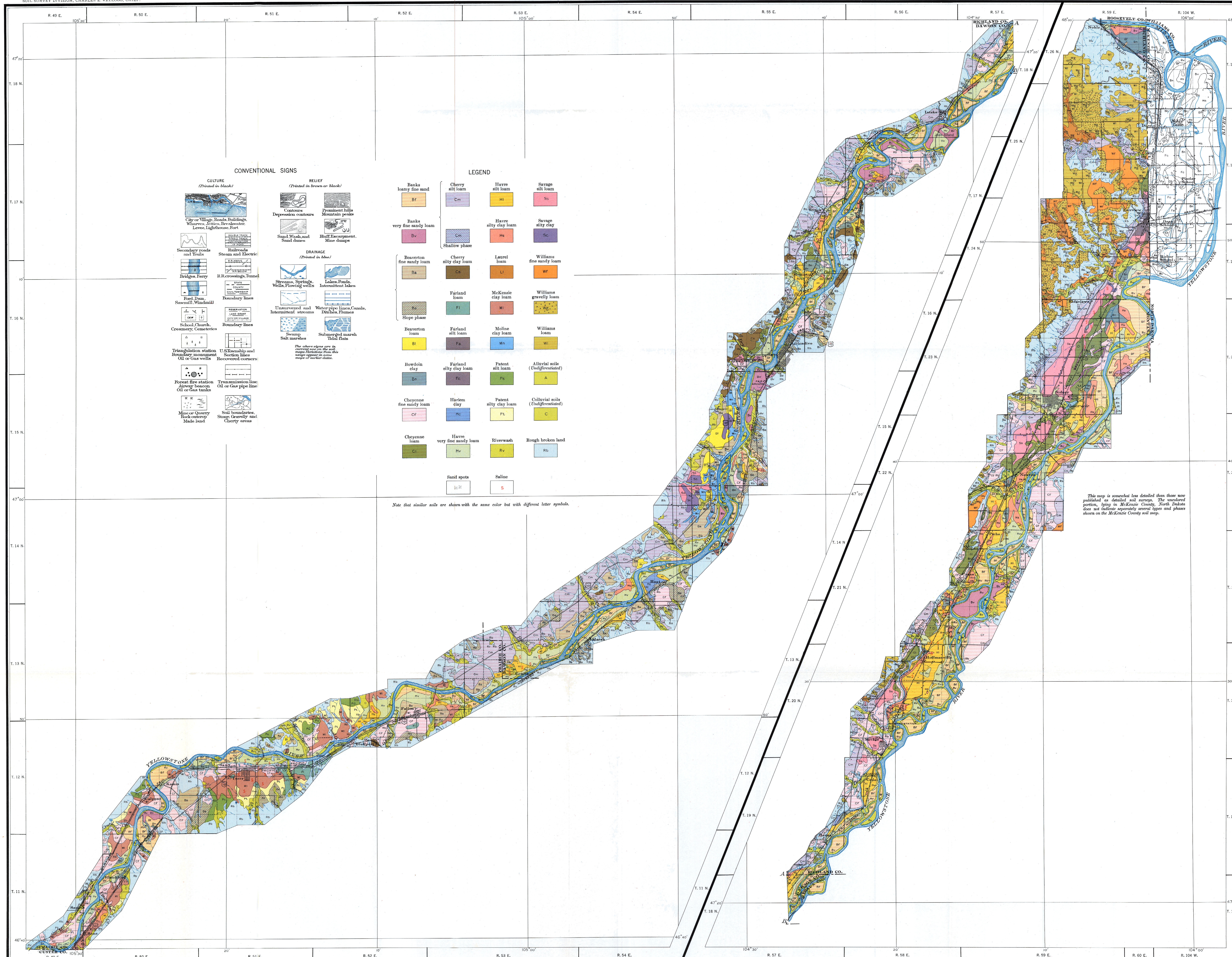


Thomas D. Rice, Inspector, District 3.
Soils surveyed by William De Young, in charge, and
F. K. Nunns, Montana Agricultural Experiment Station, and
L. H. Smith, U. S. Department of Agriculture.

DIAGRAM OF TOWNSHIP

| | | | | | |
|---|---|---|---|---|---|
| 6 | 5 | 4 | 3 | 2 | 1 |
| 7 | 8 | 9 | 10 | 11 | 12 |
| 18 | 17 | 16 | 15 | 14 | 13 |
| 19 | 20 | 21 | 22 | 23 | 24 |
| 30 | 29 | 28 | 27 | 26 | 25 |
| 31 | 32 | 33 | 34 | 35 | 36 |

Scale 1 inch = 2 miles

2 1 0 2 4 6 Miles

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